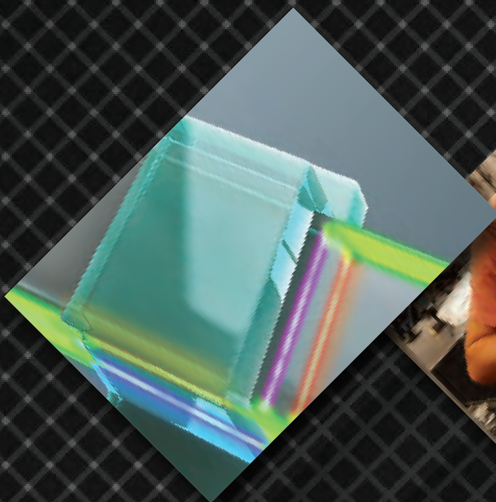
UCLA HENRY SAMUELI SCHOOL OF ENGINEERING AND APPLIED SCIENCE



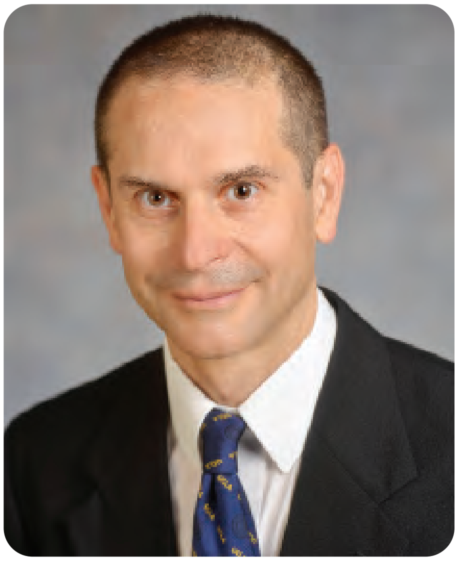

ECE

ELECTRICAL AND COMPUTER ENGINEERING

ANNUAL REPORT
2016
2017

UCLA Electrical and Computer Engineering: A New Era

We meet the academic year with a new name: Electrical and Computer Engineering. This name reflects the fact that for many years we have had strong research and educational presence in computer engineering. We will now be accurately advertising the breadth of activities taking place in the Department. As part of the two-year planning process accompanying this change, we have jointly designed with the Computer Science Department a new B.S. degree in **Computer Engineering** with two tracks: embedded networked systems such as the Internet of Things, and data science. This complements the existing B.S. degree in **Electrical Engineering**. The M.S. and Ph.D. degrees will be named **ECE**.



Chair Gregory Pottie

We are also continuing to roll out our **Fast Track** program by expanding the number of honors courses offered, to create the first honors program in UCLA Engineering. We are also undertaking a top to bottom review of our undergraduate and graduate instructional programs, including instructional methods, technologies and assessment, topic sequencing, and design, writing and entrepreneurship threads in the curriculum. Arguably, the educational infrastructure of the nation is largely focused on training students for the mass production industries of the 20th Century, rather than the rapidly evolving and interdisciplinary personal products and services structure of the 21st Century. What is meant by degrees in electrical and computer engineering will need significant re-working. We are assessing what topics every ECE student must take, what topics should be available within the curriculum, and which extracurricular experiences we should support including club experiences, industry-led workshops, internships, and alumni advising. These activities are part of the Dean's strategic planning for 2017/2018.

At our annual departmental retreat, Professor **Asad A. Abidi** observed that ECE research is now entering a period of exceptional challenge and opportunity. Up until recently we were following clear roadmaps in integrated circuits and communications: CMOS scaling and achieving the Shannon limits. Through many years of creative activity by the profession, we have reached the end in each, but our society depends more than ever on continued scaling of processing and communication as information technology becomes pervasive in expanding spheres of daily life.

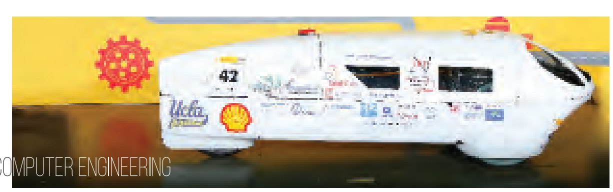
The two main ways to continue to improve processing speed and efficiency are bringing software functions into hardware through a mix of new architectures and design tools, and over the longer term, development of new devices for processing and storage. Some of the UCLA research activities are highlighted on pages 4-14. Faster communication requires new materials, devices and architectures to make use of higher frequency bands from the mm-wave regime up to teraheartz. Some exciting research activities in the ECE Department are highlighted on pages 12-13. Finally, many faculty are engaged in research collaborations in applications related to medicine, as discussed on page 16.

Dean Murthy is moving the School towards concrete actions in increasing our diversity to reflect the population we serve as a public university. Two initiatives stand out. The first is a broad-based effort to increase the number of women attracted to engineering as undergraduates, graduate students and faculty. A new **Women in Engineering** organization is being created, with the launch of new programs in the coming academic year. Similarly, a new staff position has been created to support a closer relationship between UCLA Engineering and California community colleges. The objective is to remove all the barriers that transfer students face by supporting creation of new engineering courses, student organizations, internship opportunities and transition scaffolding, in collaboration with community college and industry partners.

The mission of the University of California is to educate not only our current students, but the state as a whole. This is a forward-looking vision that has stood the test of time. The **UCLA ECE Department** is embracing this concept with enthusiasm, through our educational, research, and service activities. We hope that you will join with us in this noble enterprise.

2016-2017 Annual Report

Table of Contents



NEW FACULTY

Aydin Babakhani Researches Complex Chip-Scale Sensors

Today's silicon process technology makes it possible to integrate everything from antennas to processors on a single chip at almost no cost. This creates new opportunities for implementing complex sensors and systems on a millimeter scale. **Associate Professor Aydin Babakhani** focuses on building integrated sensors and spectrometers based on silicon technology.

Wirelessly-Powered mm-Sized Sensors

Professor Babakhani builds single-chip wirelessly powered medical devices to record neural signals, stimulate neurons, record electrical activities of heart, enable minimally invasive wireless pacing and defibrillation, induce pulse hyperthermia on cancerous tumors, and enable bioelectronics medicine. Recently, his team demonstrated wireless pacing of a living heart in large animals (sheep and pig) based on a custom single-chip pacemaker equipped with on-chip antennas. They have also developed wirelessly-powered implantable chips to stimulate sciatic nerve and trigger leg movement in rodents.

In addition to medical applications, his group builds wirelessly powered sensors for infrastructure monitoring. This technology brings an unprecedented level of monitoring to oil/gas wells, reservoirs, pipelines, dams, and subsea infrastructures. These mm-sized sensors are designed to perform critical measurements in harsh environments and previously impossible locations thousands of feet under the ground.

DC-to-THz Sensors and Systems in Silicon

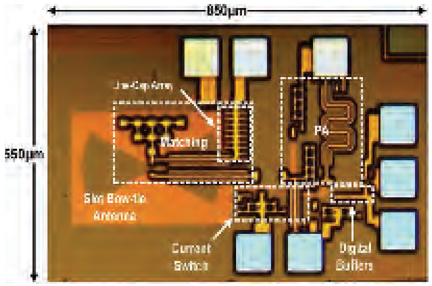
Professor Babakhani investigates techniques to produce and detect broadband THz signals based on integrated silicon technology. He has invented the technique of direct Digital-to-Impulse (D2I) radiation. His team demonstrated generation and radiation of 1.9 psec broadband pulses with a GHz repetition rate. They have also produced electromagnetic signals at 1.1THz with line-width of 2Hz and applied this technology for gas spectroscopy, hyper-spectral imaging, and high-speed wireless communication.

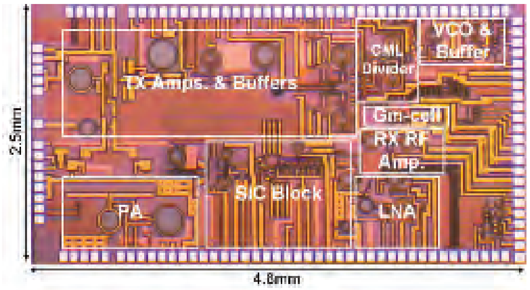
Miniaturized Magnetic Resonance Spectrometers

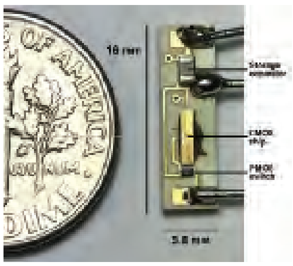
Professor Babakhani builds miniaturized magnetic resonance spectrometers. His team has reported the first single-chip transceiver to perform Electron Paramagnetic Resonance (EPR) spectroscopy. They have applied this technology to measure the EPR signature of free radicals and paramagnetic chemicals. Their EPR sensor technology has been successfully deployed in major oil and gas fields across the world. The technology is used to monitor concentration of asphaltenes (a chemical that clogs oil wells) in real-time and to minimize the use of environmentally hazardous chemical inhibitors in energy production.

Integration of CMOS Photonics and Electronics

Prof. Babakhani's team works on integrating complex electronics and photonics systems on a single chip. They have demonstrated fast optical photodiodes, waveguides, and modulators in a commercial CMOS process technology. They have integrated an entire receiver with on-chip photodiodes on a silicon chip with an area of smaller than $0.1mm^2$. The chip can support data rates as high as 2.5 Gbits/sec. In addition, his group has demonstrated sub-picosecond wireless time transfer using a line-of-sight (LOS) optical link. This chip can transfer time and frequency to remote locations with a high precision. His near-term goal is to build a massive array of optical receivers with integrated photodiodes and thereby enable a wireless link that can support data rates up to 1 Tbits/sec. He also plans to build a giga-frames/second camera, for capturing scenes and events that last less than 1 nsec.







Picosecond pulse radiator producing electromagnetic waves beyond 1THz; Single-chip transceiver for EPR spectroscopy; Wirelessly powered pacemaker with on-chip antennas

Audrey Pool O'Neal Will Lead Women in Engineering Program

Audrey Pool O'Neal, a lecturer in Mechanical and Aerospace Engineering and former senior manager with General Motors, has been named director of the **Women in Engineering** program at the UCLA Henry Samueli School of Engineering and Applied Science (**WE@UCLA**). Through academic reinforcement, mentorship, team-building, research experiences, industry internships, and personal and professional development activities, WE@UCLA will provide a unique environment for female students to thrive in engineering and computer science.

"At the undergraduate level, women who attend UCLA Engineering will be part of an active learning community, with the sole focus of ensuring their academic and professional success," said Jayathi Murthy, dean of UCLA Engineering. "Upon graduation, these women will join a network of more experienced female engineers who can continue to foster a supportive and collaborative environment for new engineers and computer scientists."

In February, Joanne Maguire, a UCLA alumna and former aerospace executive, funded a new endowment to provide scholarships to members of the UCLA chapter of the Society of Women Engineers, and the Samueli Foundation recently announced a $20 million gift to support expanding the diversity of undergraduate students in engineering and computer science. The Samueli Foundation Engineering Undergraduate Scholarship Fund will provide financial support and a research or industry internship early in the student's undergraduate program to connect academic studies to real-world experiences.


Audrey Pool O'Neal

"Engineering and computer science are demanding, exciting and rewarding careers, but they also pose unique challenges to women, both academically and socially," O'Neal said. "My job is to make sure women understand those challenges and have the skills to meet them successfully."

O'Neal received her Ph.D. and master's degrees from UCLA in mechanical engineering. Her research is in the area of multifunctional nanocomposite materials.

In addition to her academic duties, O'Neal most recently served as associate director of Undergraduate Programs for the UCLA Center for Excellence in Engineering and Diversity, which focuses on research, academic performance, and retention strategies for UCLA students who are traditionally underrepresented in engineering and computer science.

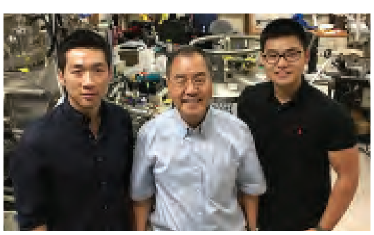
Research Offers Evidence of Majorana Particle

Rendering of superconductor and magnetic topological insulator in which Majorana particle signs were observed

A research led by **Kang Wang**, a distinguished professor who holds the Raytheon Chair in Electrical Engineering, has found a "smoking gun" signature of the long sought-after Majorana particle. The particle, whose existence was first proposed by Italian physicist **Ettore Majorana** in 1937, could be the foundation for a class of robust topological quantum computers.

"Imagine that bits of data in standard computers are like cars traveling both ways on two-lane highways," said Wang. "A quantum computer could have many lanes and many levels of 'traffic,' and the cars could hop between levels and travel in both directions at the same time, in every lane and on every level. We need stable, armored quantum 'cars' to do this and the Majorana particles are those supercars."

Because the Majorana particle is its own anti-particle — carrying zero electrical charge — it is viewed as the best candidate to carry a quantum bit, or **qubit**, the unit of data that would be the foundation of quantum computers. Unlike "bits" of data in standard computers, which can be represented as either 0s or 1s, qubits have the ability to be both 0s and 1s, a property that would give quantum computers exponentially more processing power and speed than today's best supercomputers.



Qing Lin He, Kang Wang and Lei Pan

The Majorana particle has been the focus of interest for quantum computing in large part because its neutral charge makes it resistant to external interference and gives it the ability to leverage and sustain a quantum property known as entanglement, generating enormous computing power.

For their research, published in **Science**, the team set up a superconductor, a material that allows electrons to flow freely across its surfaces without resistance, and placed above it a thin film insulator, to give the engineers the ability to manipulate the particles into a specific pattern. After sweeping a very small magnetic field over the setup, the researchers found the Majorana particles' distinct quantized signal — the telltale fingerprint of a specific type of quantum particles — in the electrical traffic between the two materials.

"The Majorana particles show up and behave like halves of an electron, although they aren't pieces of electrons," said **Qing Lin He**, a UCLA postdoctoral scholar and the paper's co-lead author. "We observed quantum behavior, and the signal we saw clearly showed the existence of these particles." In the experiment, Majorana particles traveled along the insulator's edges in a distinct braid-like pattern. The next step will explore how to use Majorana particles in quantum braiding, to allow information to be stored and processed at super high speeds.

Lei Pan, a UCLA doctoral student in electrical engineering and the paper's co-lead author, said Majorana particles' unique properties make them especially useful for topological quantum computers. "While conventional quantum systems have sophisticated schemes to correct errors, information encoded in a topological quantum computer cannot be easily corrupted. What's exciting about using Majorana particles is that the system would be fault-tolerant."

The paper's authors include **Xufeng Kou**, who earned his master's and doctoral degrees at UCLA and is now a member of the faculty at **Shanghai Tech University**, in collaboration with **Jing Xia**, a professor at **UC Irvine**, **Kai Liu**, a professor at **UC Davis** and **Shou-Cheng Zhang**, a professor at **Stanford University**. *— by Matthew Chin*

Asad M. Madni Receives Six Major Honors and Awards

Distinguished Adjunct Professor **Asad M. Madni** was awarded a Chair Professorship and an Honorary Doctor of Philosophy Degree by the **National Chiao Tung University**, Hsinchu, Taiwan in 2016, "in recognition of his outstanding achievements in science, engineering, technology innovation, and corporate management." After the ceremony, Professor Madni delivered a lecture, "Grand Challenges for Engineering Proposed by the U.S. Academy of Engineering," for faculty, students, staff, visiting scholars and distinguished guests.

In 2016, the **Institute of Electrical and Electronics Engineers**, San Fernando Valley Section, presented Professor Madni with the **Visionary Leadership Award** "for visionary leadership, remarkable innovations, and seminal and pioneering contributions to science and technology that have had a worldwide impact and significantly benefited humanity."

In recognition of his visionary leadership, Professor Madni was awarded the **2017 Gordon Medal** and distinction of Gordon Fellow, for Engineering Leadership, from the Bernard and Sophia Gordon Engineering Leadership Center at The Jacobs School of Engineering, University of California, San Diego.

The **Royal Aeronautical Society (RAeS)** U.K., elected Professor Madni a **RAeS Fellow**. Established in 1866, the Society has been at the forefront of developments in aerospace, seeking to promote the highest professional standards and provide a central forum for sharing knowledge.

The Government of India's **NRI Welfare Society** awarded Professor Madni the **2017 Mahatma Gandhi Pravasi Samman Gold Medal**. The official award ceremony will take place at the House of Lords, London, U.K. The Medal is awarded to recognize people of Indian origin for their outstanding contributions in their respective fields in the country of their residence and in the service of the wider global community.

The **IEEE - Eta Kappa Nu (HKN)** awarded Professor Madni the Vladimir Karapetoff Outstanding Technical Achievement Award, a major IEEE-HKN recognition for career accomplishment in the field of electrical and computer engineering. It dates from 1922, when the Board of Governors established the award in honor of Vladimir Karapetoff, an IEEE Fellow and a prominent member of Eta Kappa Nu. This major recognition is presented to a practitioner of electrical or computer engineering who has distinguished himself/herself through an invention, development, or discovery in the field of electrical or computer technology. Factors considered in bestowing this award include the impact and scope of applicability, the impact on the public welfare, and the impact on the standard of living and/or global stability.

Professor Madni (with Professor Chang) at National Chiao Tung University

Educational Program Innovations

The 2017/2018 academic year will see major education program planning activities at the levels of the Campus, School and Department. At the Campus level, task forces met throughout the prior year for the UCLA Innovation initiative, which encompasses civic engagement, global impact, research, and institutional effectiveness in addition to transformation of education.

The goal is to use the latest data and research driven approaches to improve the educational experience at UCLA and to determine what incentives and infrastructure need to be put in place to enable this. The Office of Instructional Development has been re-structured, with new programs in place for improving the training of faculty and teaching assistants in evidence-based instructional techniques such as active learning and criterion-based grading.

Associate Dean **Richard Wesel** is leading the School's own strategic planning for education. Goals for the undergraduate program include creation of threads providing practice in writing, oral expression, design, computation and entrepreneurship throughout the four years. Requirements for foundations (math, science, and discipline-specific) and breadth will be reviewed to determine what is needed for careers that will likely outlast industries in the fast-changing environment of the 21st Century. The set of technical electives and extracurricular activities will be reviewed so that every student has the opportunity to be exposed to the latest technology in their chosen areas of specialization. All of this must be accomplished without increasing the number of units required for graduation.

We are increasing industry and alumni participation in design activities and instruction of skills, both within the curriculum and in those directed by student organizations. These activities work in parallel to training of instructors, and the use of undergraduate learning assistants to help students in skill building.

Additionally, planning has proceeded for creation of a new maker space within the School adjacent to the **Student Creativity Center** in Boelter Hall. This will provide resources for student organizations, individual projects, design courses, and potential new capstones in entrepreneurship. The School is also providing new staff support for extracurricular activities.

Two new positions have been created to oversee summer research, increase industry internship opportunities, and enhance interactions with the community college system. A committee under the leadership of Professor **Gregory Pottie** is engaged with how to reduce the many barriers confronting transfer students in transitioning to four-year schools, including lack of engineering courses, internship and research opportunities, and prior engagement with student organizations. Our goal is to make the transition smoother and reduce time to degree. At the Department level, besides participating in the School's strategic planning process, we are actively engaged with rolling out the first honors program in engineering at UCLA, and implementing the **Computer Engineering Degree**.

As part of this planning, a faculty committee under the leadership of Professor **William Kaiser** has been charged with determining what sequence of tools and devices students should be exposed to in the curriculum from freshman through senior year, so that by the end they see industry-standard tools. We are also working to enable more students to be able to take advantage of the many extracurricular experiences that can lead to a more fruitful career. For these purposes, the department has hired **Gabriela Ledezma** as our inaugural undergraduate program officer. She will organize information and support events, assist with recruitment, create databases of internship and research opportunities, and help connect students with alumni and campus resources.

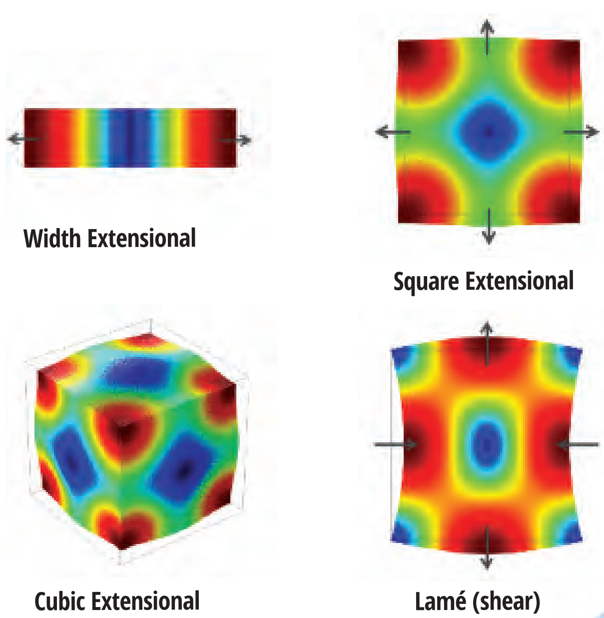
— Gregory Pottie

Resonators and Akhiezer Damping

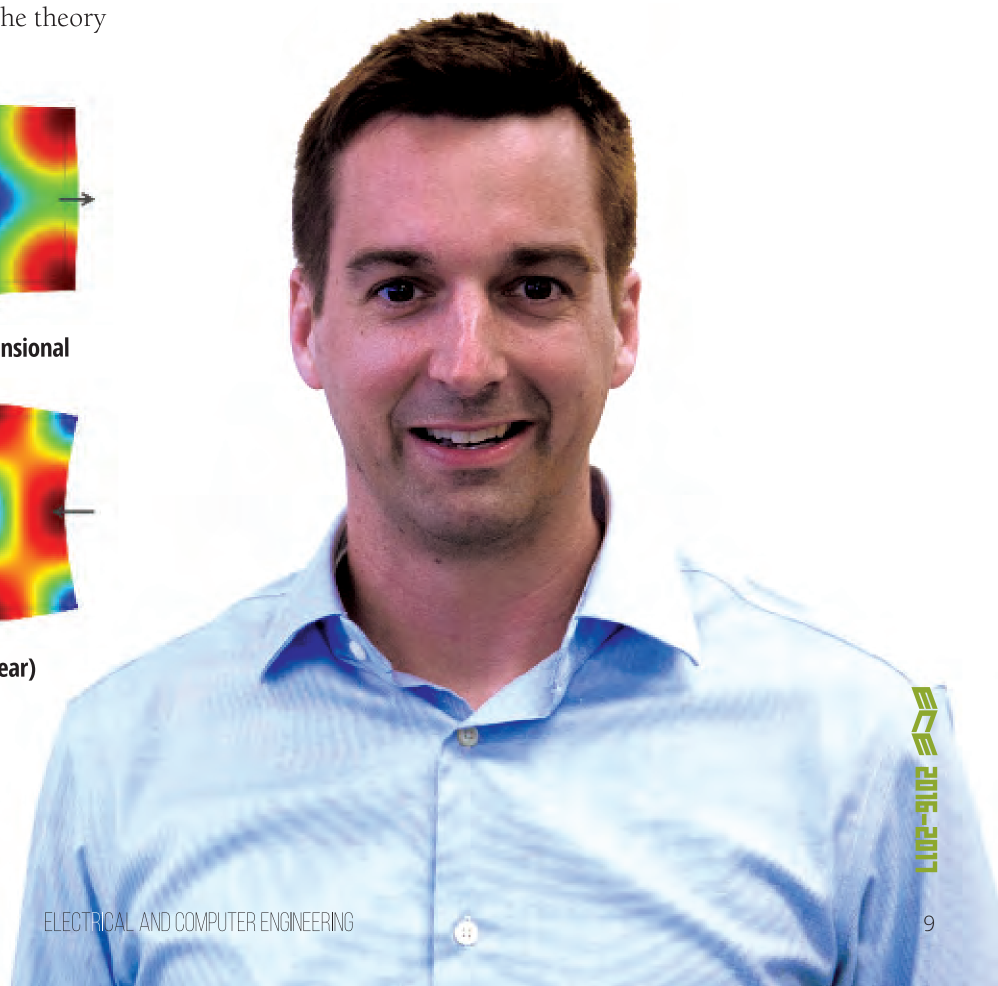
Like a metronome in music, resonating devices provide the timing reference for communication between the numerous wireless devices we use everyday, including phones, watches, and even smart appliances. However, a metronome typically beats around once every second, whereas the resonators in modern electronics operate at millions (MHz) or billions (GHz) of cycles every second. For devices that operate in the GHz frequency range, there remains a lack of fundamental understanding about how the devices work. In particular, much remains to be learned about the ways in which energy dissipation occurs in the devices, which is important because energy dissipation directly affects the noise in the devices when operated as frequency references.

To address this lack of understanding, researchers in the **Sensors and Technology Laboratory (STL)** directed by Professor **Rob Candler** have developed a new formulation for phonon-based energy loss in these devices, essentially the ways in which mechanical vibration energy is irreversibly converted to heat. The theory for this type of phonon-based energy loss, named Akhiezer damping after its original discoverer, has remained largely unchanged for several decades.

In particular, there was a long held assumption that Akhiezer damping depends only on materials and is therefore independent of the resonator design. The work performed in STL upended this assumption, showing that the crystal vibrations, called phonons, are dissipated to heat in a way that highly depends on the resonator's shape of vibration. With confirmation of the design dependence of Akhiezer damping, the team can now make recommendations for designs with minimum energy dissipation and has shown that different resonator designs have a difference in energy dissipation as large as 40X. The reductions in energy dissipation enabled by this modeling could have impacts beyond timing references to other applications, including inertial sensing and precise sensing of biological and chemical species.



Professor Rob Candler and his student developed a new theory and simulation method for Akhiezer damping in micromechanical resonators

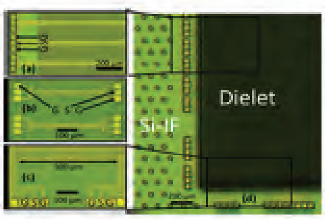


UCLA Center for Heterogeneous Integration and Performance Scaling

The UCLA Center for Heterogeneous Integration and Performance Scaling (CHIPS) is an interdisciplinary university-led consortium with leading industrial partners and universities with the support of government agencies to address the dramatic changes taking place in the electronic hardware arena. Led by Professor **Subramanian Iyer**, UCLA CHIPS develops core hardware technology, devices and applications in the area of microelectronics and advanced packaging.

Advanced Heterogeneous Packaging

Our work is focused on enabling package and board level scaling to achieve a more holistic implementation of "Moore's Law" enabling heterogeneous integration similar to monolithic SoCs. We have pioneered the concept of the high-density Silicon Interconnect Fabric (Si-IF) as a general platform for interconnecting diverse dielets at ultra-fine pitch (down to 2µm) and have extended the concept to Fan-out Wafer level processing to bio-compatible flexible substrates (Flextrate™) with low die-shift. We also investigate extendible methods of monolithic integration that allow for wafer level stacking at fine pitch.



The capabilities that we are developing open doors to new methods of integrating diverse systems including substantial reduction in inter chip communication power, more intimate integration of memory and logic, scale-out of ultra large systems, scaling of memory and neuromorphic systems, power management and distribution, as well as the implementation of new concepts in medical engineering. With strong collaboration from our consortium partners, we provide paths to design methodology and enablement, thermal management, novel materials, advanced tooling and equipment, instrumentation, and cost effective high yield manufacturing.

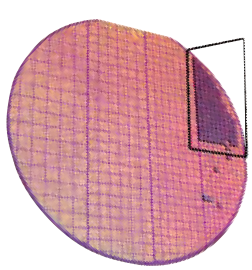
Devices and applications

UCLA CHIPS also leverages new device technology to build advanced circuits and systems. Besides applications of our advanced packaging efforts, we have pioneered the development and use of the Charge Trap Transistor (CTT) as novel embedded digital and analog memory, and are leveraging its use in scalable neuromorphic systems. We have also employed industry AI platforms to interpret medical imaging and provide easy identification of biological markers.

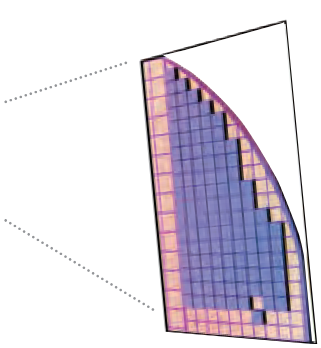
Example of Flextrate™ around a pen

Our main achievements to date include:

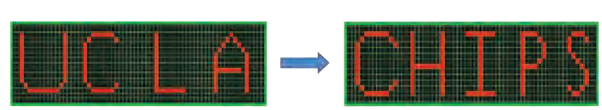
The development of a baseline process for sub-10µm pitch dielet to Si-IF and the integration of multiple dielets (over 3000mm²) on a single Si-IF board at 10 µm pitch and 100 µm inter dielet spacing; the development of the bio-compatible Fan-out based Flextrate™ process with high density interconnects and minimal die shift; and the implementation of the CTT for logic compatible embedded digital memory as well as for neuromorphic systems for both supervised and unsupervised learning.



Si-Interconnected Fabric (Si-IF)



Si-dielets bonded onto Si-IF with 10µm pitch and 100 µm inter-dielet spacing



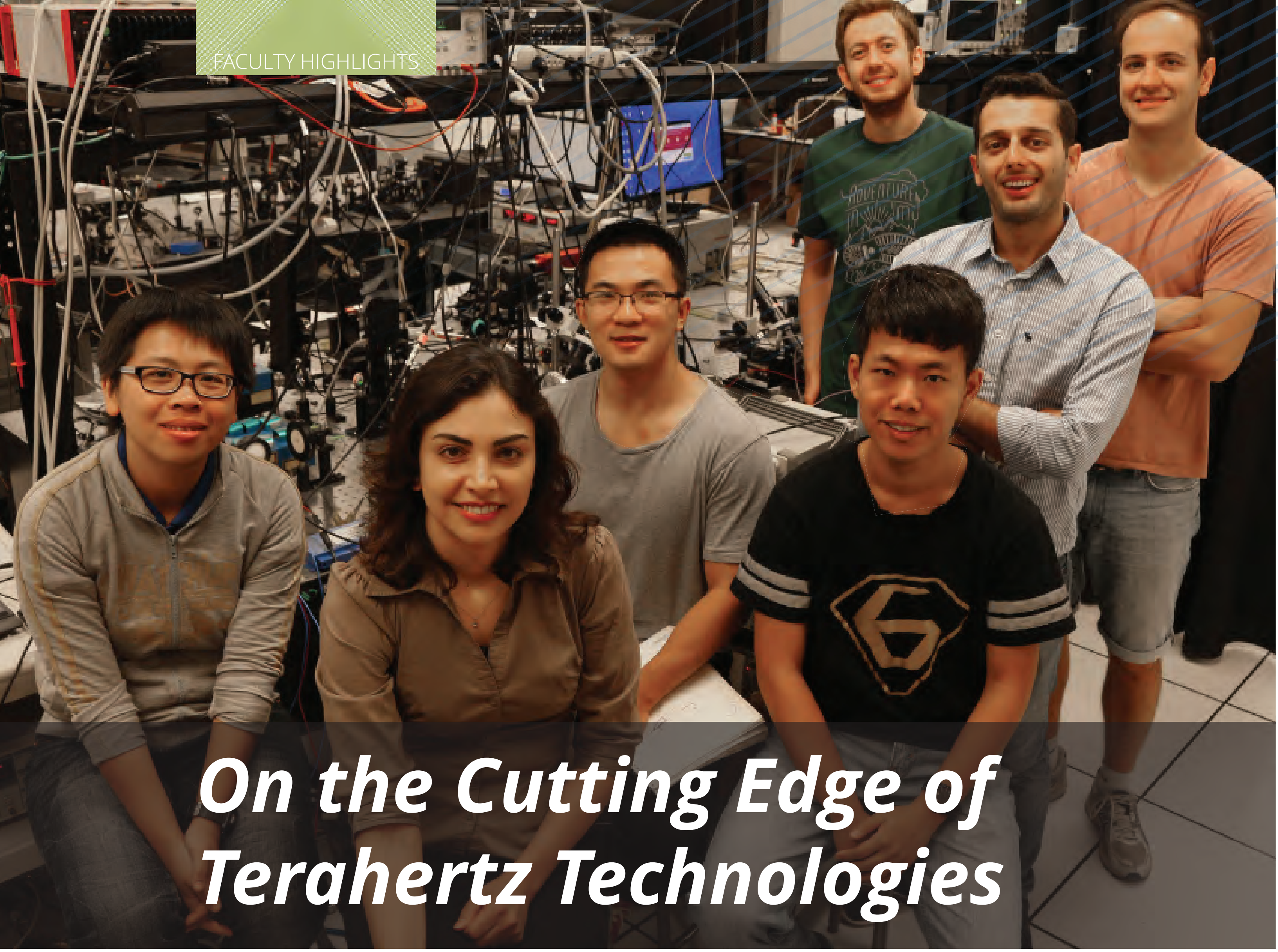
Reprogrammability of a CTT array

Professor Dan Goebel Nominated a Fellow at Jet Propulsion Laboratory

NASA's **Jet Propulsion Laboratory** announced the selection of the 2017 class of **JPL Fellows** — a position on the top of the Laboratory's individual contributor career ladder, recognizing those few who have made extraordinary technical and institutional contributions over an extended period of time. The selections are the consensus outcome of a rigorous process that included current JPL Fellows, management representatives from the JPL Directorates, and a subgroup of the JPL Executive Council.

This year, UCLA Electrical and Computer Engineering Adjunct Professor and Senior Research Scientist at JPL **Dan M. Goebel** was selected for this honor, along with four other new members. His nomination cites "seminal work in conceptualizing, implementing, and troubleshooting electric propulsion technology for NASA missions, such as **Dawn** and **Psyche**, and serving as a JPL expert in other emerging mission technologies, including microwave sources, advanced plasma sources, high voltage engineering, and ultra-linear traveling wave tube amplifiers."

Dan Goebel is a member of the **National Academy of Engineering** and the **National Academy of Inventors**, and a Fellow of the **IEEE**, **AIAA** and **APS**. He holds 52 patents and is the author of over 125 technical journal papers, 150 conference papers, 8 book chapters, and the book (with I.Katz) *Fundamentals of Electric Propulsion*. He is an internationally recognized expert in electric propulsion, microwave sources, advanced plasma sources and high voltage engineering. He received his Ph.D. from the UCLA Electrical Engineering Department in 1981.



On the Cutting Edge of Terahertz Technologies

New metamaterial dramatically improves terahertz imaging, sensing and communication systems

A research team led by **Professor Mona Jarrahi** has developed an artificial composite material to control higher-frequency electromagnetic waves, such as those in the terahertz and far-infrared frequencies.

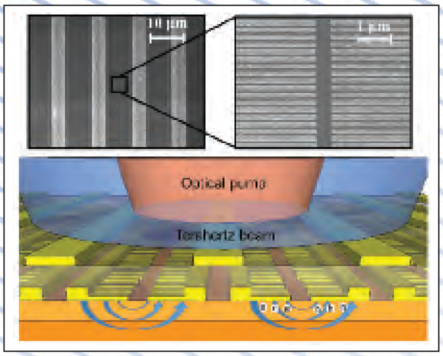
The material, specifically a metamaterial because it has properties not found in nature, could be transformative for imaging, sensing and communication applications. It could be used for quality control in pharmaceutical production lines, scanning pills at high speeds to look for any defects; to spot cancerous tumors at early stages using tomography; or for forming adaptive high data-rate communication channels.

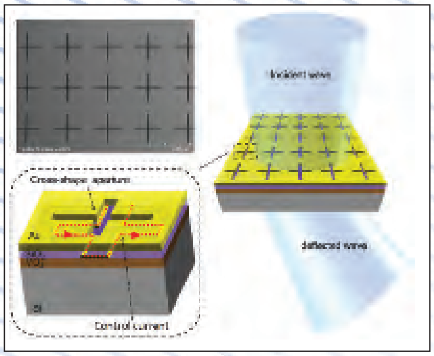
"Terahertz frequencies in particular offer some unique advantages, for example they can 'see' some details not otherwise 'visible' in other parts of the spectrum," said Mona Jarrahi. "However their use is not widespread. Current systems require a mechanical scanning technique to steer or guide the focus area of the terahertz beam, much like how an office copy machine uses a moving arm underneath the glass to capture an image."

Despite extensive progress developing mechanical beam-steering techniques through miniaturization and the utilization of micro-electro mechanical systems, the potential use is still limited. Those tiny systems are complex with moving parts and for terahertz-based systems, they have not been practical. The team's solution is simple.

"Our new metamaterial acts as a kind of moving lens that can focus on different areas of an object, but instead of being moved mechanically, its focus point is instead controlled electronically by changing an electric current that moves through it," Jarrahi said. "The material itself never moves."

The material is made up of metal-coated vanadium dioxide on silicon and is punctured with cross-shaped openings. It would be placed in front of the radiation





Nanoantenna arrays for high-sensitivity terahertz detection (left)

The metamaterial with cross-shaped openings can deflect a terahertz beam's angle (right)

beam used in an imaging or sensing application. Depending on the level of electric current, the material can deflect the beam's focus point by as much as 44 degrees, both vertically and horizontally.

The new technology could lead to imaging, sensing and communication technologies in terahertz and far-infrared frequencies that are more reliable, compact, cost-effective and faster than the current state-of-the-art.

This work has been published online in Scientific Reports and supported by the **National Science Foundation**. The lead author on the paper was **Mohammed Reza Hashemi**, a postdoctoral scholar at UCLA and member of Jarrahi's lab. Other authors include UCLA graduate student **Shang-Hua Yang**, and **Tongyu Wang** and **Nelson Sepulveda**, a graduate student and an associate professor, respectively, at Michigan State University's College of Engineering.

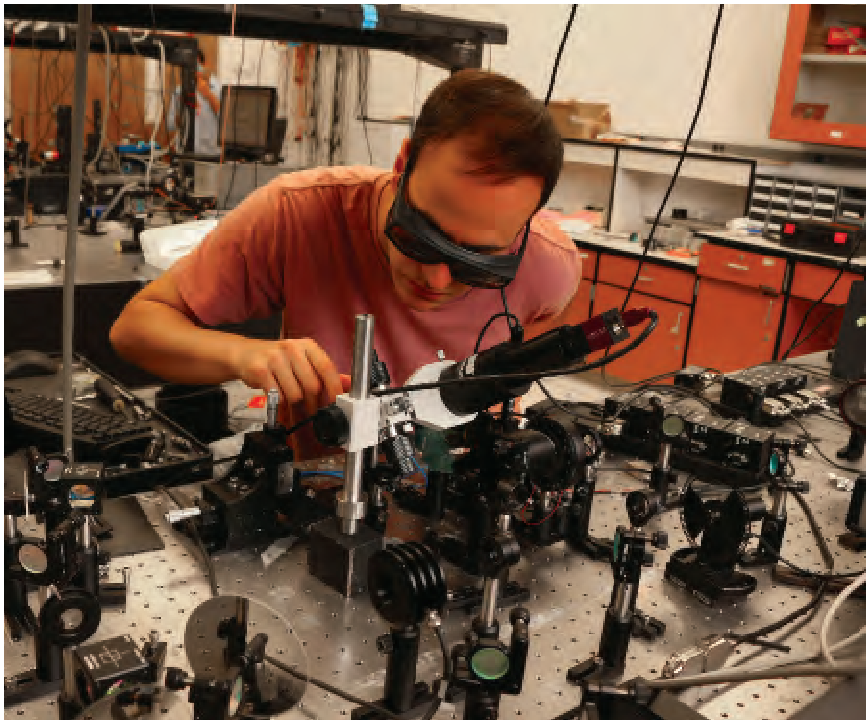
Terahertz nano-antenna array can find faint target signals

Professor Mona Jarrahi led a research team that developed a new antenna array that greatly expands the operation bandwidth and level of sensitivity for imaging and sensing systems using terahertz frequencies.

Terahertz frequencies are an underused part of the electromagnetic spectrum that lies between the infrared and microwave bands. The unique features of this part of the spectrum could be useful for biological sensing and medical imaging, chemical identification and material characterization. However terahertz technology is not yet mature. One component researchers are aiming to make more efficient is a terahertz detector, which receives the terahertz signals, much like photodetectors in a camera that sense light to produce an image.

By operating across a broader bandwidth, the new nanoscale antenna array developed by **Jarrahi** and **Nezih Tolga Yardimci**, a UCLA graduate student in electrical and computer engineering, can extract more information about material characteristics. The device's higher signal-to-noise ratios mean it can find faint target signals. For example, the new terahertz detector can be tuned to detect certain chemicals even when target molecules are present in miniscule amounts. It can also be used to image both the surface of the skin, and deeper tissue layers.

The unique nanoscale geometry of the antenna array addresses the bandwidth and sensitivity problems of previously used terahertz detectors, the researchers said. "Up close, it looks like a row of small grates," Yardimci said. "We specifically designed the dimensions of the nanoantenna elements and their spacing such that an incoming



Graduate student Nezih Tolga Yardimci, aligning the nanoantenna arrays for terahertz detection

terahertz beam is focused into nanoscale dimensions, where it efficiently interacts with a stream of optical pump photons to produce an electrical signal proportional to the terahertz beam intensity."

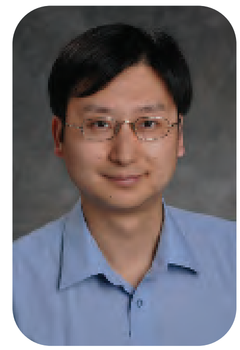
Jarrahi said: "The broad operation bandwidth and high sensitivity of this new type of terahertz detector extends the scope and potential uses of terahertz waves for many imaging and sensing applications."

The research was published in Scientific Reports and supported by financial support from **Moore Inventor Fellowship** and the **Presidential Early Career Award for Scientists and Engineers**.

Time-Varying Circuits Break the Limit of Passives for Future Wireless Systems

Passive electromagnetic devices such as transmission lines, filters and antennas are essential parts of a wireless system. They often dominate the efficiency, bandwidth and noise performance. Traditional passives are built with materials and structures that have time independent properties. They have limited flexibilities and can hardly be tuned without incurring a great penalty in performance. Additionally, passives are subject to many well-known fundamental limits such as the reciprocity limit in transmission, quality factor limit in resonators and efficiency bandwidth product limit in electrically small antennas. Utilization of transistor based active electronics may help to overcome some of these challenges but they oftentimes incur noise and power handling disadvantages.

Professor Y. Ethan Wang's work at **UCLA Digital Microwave Lab** aims at breaking those well-known limits in passives through the development of a new class of electro-magnetic devices that are operated in a time-varying fashion. The time-dependent property of these devices including transmission lines, filters and antennas can be created through semiconductor physics or electro-mechanical interactions, which also allow them to be constructed on integrated circuits (IC) platforms for precision production and system integration. Through addition of the new time dimension, several of these fundamental limits of passives can be lifted and advanced signal processing functions can be performed directly at the radio frequency with these devices which will significantly improve the performance of existing wireless systems.



Y. Ethan Wang

One example of such devices is **Time-Varying Transmission Line (TVTL)** whose impedance is a function of time through external parametric modulations. These transmission lines possess extraordinary properties such as non-reciprocal transmission, zero loss frequency conversion and unidirectional amplification with almost no noise penalty. An IC version of such a transmission line is shown in **Figure 1**. These chips can be used as a fundamental building block to realize sophisticated RF functions such as correlators and tunable filters, which may become critical components in the upcoming 5G wireless communication systems.

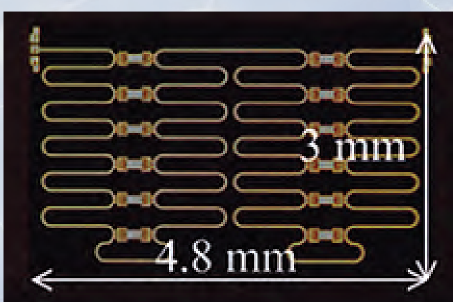


Figure 1: Picture of a TVTL chip fabricated with Northrop Grumman's 0.2µm GaN process

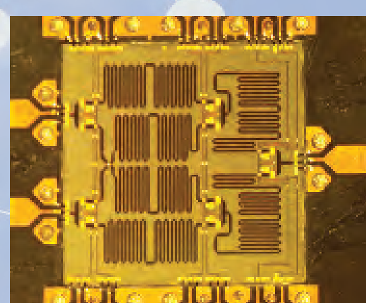


Figure 2: Picture of a SSDL circulator chip fabricated with Raytheon's 0.15µm GaN process

Another example is **Sequentially Switched Delay Lines (SSDL)** which consists of multiple transmission lines that are interconnected with switches whose turning on and off actions are synchronized with the propagation of the electromagnetic waves on those lines. It is demonstrated that electromagnetic waves traveling toward different directions can be routed to different ports, smilarly to how traffic flows are routed by traffic lights to different streets without any additional delay. Such a device is called a circulator and it allows non-reciprocal wave propagation being achieved on a IC without the need of magnetic material. **Figure 2** shows a picture of the on-chip realization of such a device. As the bandwidth of such circulators is fundamentally unlimited, radios that simultaneously transmit and receive information in any desired frequency through a single antenna may be built with such devices, enabling the next generation wireless systems such as cognitive radios.

These innovative projects are conducted in collaboration with aerospace giants such as Boeing and Northrop Grumman, with the strong support of initiatives such as the **DARPA SPAR** program and the **NSF EFRI** program.

Department Initiatives

NASA's James Webb Space Telescope, due to deployment in 2018. The project is headed by Alumni Jon Arenberg

Undergraduate Seminar EE 1

During Spring Quarter, a new class for first-year Electrical and Computer Engineering students was introduced. It was designed to provide information about the ECE major and what ECE alumni do in their careers after they graduate. Six alumni and two faculty members were invited to speak. The alumni are approximately 5-10 years after graduation, and are working in diverse industries and companies, including Disney, Facebook, Northrop Grumman, Texas Instruments, Western Digital, and Beckman Coulter. The faculty are conducting research in biomedical devices and robotics. Half of the alumni speakers are women. The students were required to prepare a short summary of each speaker's presentation along with lessons learned. The student feedback was excellent; and the class will be presented again in Fall Quarter.

Distinguished Alumni Speaker Series

A new speaker series began in 2016. Two distinguished alumni were invited to speak to our faculty, alumni, and students, about a topic of their choice. **Dr. Jon Arenberg**, 1983, MS 1985, Ph.D. 1987, Chief Engineer, James Webb Space Telescope, Northrop Grumman, spoke about the **James Webb Space Telescope**, which he and his team are designing and building for NASA. He guided the audience through the many technical challenges that the project has encountered and overcome; and the exciting challenges that still lie ahead as the telescope is prepared for launch and deployment next year.

Professor Asad M. Madni, 1969, MS 1972, spoke about numerous "grand challenges" facing humanity that must be addressed by us as a global society to maintain our quality of life, healthcare, environment, energy needs, manufacturing efficiencies, etc., if we are to continue humanity's trajectory of progress. He described some of these major technologies and their applications including intelligent sensors and wireless sensor networks, intelligent cars and smart highways, tele-health (wireless healthcare), micro-electromechanical systems (MEMS), nanotechnology, clean technology and the smart grid, robotics and automation, and advanced signal processing, and how these technologies are currently being used and their potential future applications.

The department plans to present two or three distinguished alumni speakers each future school year.

Opportunity Network & Experience

UCLA ONE, which stands for **Opportunity, Network and Experience**, is a new software platform designed to bring alumni and current students together for personalized career advice, mentorship, and other interactions, not only between alumni and students, but also between alumni. It is operated by the UCLA Alumni Association. During the fall quarter, UCLA ONE was utilized for an alumni mentorship program between alumni and current students; and EE alumni and students were included in that program. Alumni were invited to post their career information and indicate their willingness to serve as mentors. Current students then were invited to contact these alumni and explore a possible mentorship arrangement. We hope to greatly increase participation of alumni and students this year for their mutual benefit — students hear the real story about career opportunities, and alumni have the pleasure of engaging with our outstanding and enthusiastic students. *— William Goodin*

UCLA Undergraduates Excel in Engineering and Translational Biomedical Research Program

Will researchers and scientists be able to image DNA molecules or detect waterborne pathogens in the field without having to carry heavy and costly machinery? This is becoming possible through the use of devices such as smartphones and lens-free computational microscopy tools.

Creating cost-effective, portable, mobile measurement devices form a key theme among the projects that more than 40 UCLA undergraduate researchers present every Spring quarter at the annual **Presentation & Demo Day** of the **Howard Hughes Medical Institute (HHMI)** Undergraduate Research, Training and Innovation Program, created and organized by the **Ozcan Research Group** of the Electrical and Computer Engineering Department as well as the **California NanoSystems Institute**. Students conduct hands-on experimental work in Ozcan's lab throughout the entire year, co-author publications, and present and demo their results in scientific meetings and conferences. Since 2014, undergraduate researchers have co-authored more than 30 journal articles, and more than 85 conference proceedings, also achieving ~98% retention in STEM fields after graduation. Approximately 40% of the students are female, and the students are admitted each year to this highly interdisciplinary program from various departments on campus, such as Electrical & Computer Engineering, Bioengineering, Chemical Engineering, Computer Science, Physics, and Biology, giving them hands-on opportunities to conduct cutting-edge research with applications in mobile health, telemedicine and environmental monitoring.

Professor Aydogan Ozcan (far right) with the HHMI Undergraduate Research Group

"The most fun part is when I see students own their projects in front of the audience and present their results," said HHMI Professor Aydogan Ozcan. "This ownership and peer-to-peer learning and mentorship are very exciting to see from these young researchers."

Each year, the event features approximately 10 oral presentations, 15-20 posters and 10 demos in the poster and demo viewing session, followed by an awards ceremony and banquet. The students are judged by a faculty panel as well as researchers from industry, and attendees vote for recipients of awards in various categories.

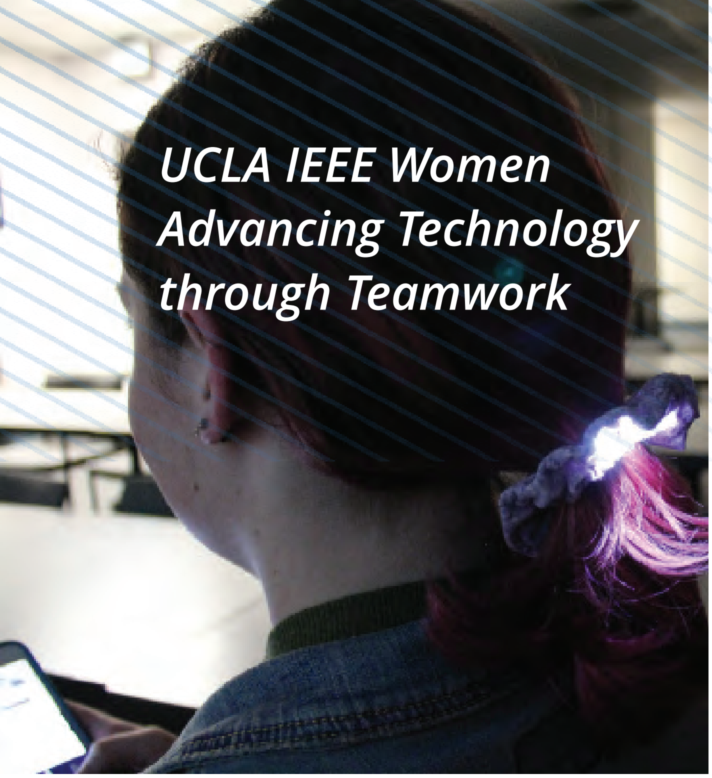
In the last year's event, **Best Poster Presentation** award went to undergrad students **Michelle Luong** and **Alex Guziak** for their project *Yeast viability analysis using on-chip imaging and machine learning*. A journal article was also published on these results, which was Luong's first. When asked about the benefits about being in the program, Luong said, "The time in the lab — I was able to use the microscope; I handled the dyes and yeasts. There was a lot more opportunity to be in the lab than some of my other friends performing research who are not in the program."

Patrick Wolf and **Kyrollos Yanny** received the **Best Oral Presentation** last year for their project, *Real-time algae and waterborne pathogen monitoring using on-chip holographic flow cytometry*. "The traditional way involves on-site manual sampling. Somebody has to go to every water source, get a sample and send it back to the laboratory for further identification. This will require a lot of manpower that we might not always have access to," Yanny said. Furthermore, programs have to rely on volunteers, which may impede the integrity of the sample. "There is a need for an on-site, real-time monitoring system that can minimize the delay between the sampling and monitoring."

The **Best Demo Award** went to **Ashutosh Shiledar**, **Jeffrey Wong**, **Shuowen Shen**, and **Xuan Chen** for *Rapid air quality measurement based on lens-free microscopy*. Their instrument consists of a micropump that drives air through an air-sampler where aerosols within the airflow are collected in a sticky coverslip. Three fiber-coupled light-emitting-diodes are then turned on, recording the scattering holograms of the collected aerosols on an image sensor chip. The captured images are transmitted to a remote server where they are reconstructed and analyzed in less than 30 seconds.

Seungkyeum Kim of the Chemical Engineering Department received the **Best Project Award** last year for his project *Single-molecule imaging on a mobile phone*. This award was determined by popular vote from both the judges and the attendees.

PHOTO BY TUNDE AKINLOYE/DEREK TSENG



UCLA IEEE Women Advancing Technology through Teamwork

UCLA WATT (Women Advancing Technology through Teamwork) is the UCLA chapter of **IEEE-WIE (Women in Engineering)**. WATT's goal is to create a space to support minorities within the Electrical and Computer Engineering community, particularly women. WATT uses electrical engineering as a common interest in order to build a community of confident, socially aware engineers.

The **emPower** mentorship program matches up first- and second-year students with upperclassmen who guide their mentees through their time at UCLA, be it academically, technically, socially, or professionally. Technical and professional workshops are also held throughout the year. They serve as opportunities for members to build their technical skills through tinkering workshops such as wearables workshops, as well as to network with the surrounding ECE community through networking events like a dinner with Intel. WATT is also unique in its focus on advocacy and mental health. WATT holds many workshops that pertain to social issues such as unconscious bias, imposter syndrome, and LGBT issues, as well as workshops related to health such as meditation, depression and anxiety, and productivity workshops.

Electrical and Computer Engineering Graduate Student and Post-doc Society (ECEGAPS)

There are many challenges associated in attaining a graduate degree; from the hours spent in the study halls to the filing of the final dissertation and all financial burdens, the sacrifices made in the pursuit of knowledge are considerable. As a foreign student, these hardships are further compounded by the language barrier, ignorance of the native etiquette and customs, and in most circumstances a general feeling of isolation. In understanding of the difficulties graduate students must endure, the **Electrical and Computer Engineering Graduate student and Post-doc Society (ECEGAPS)** was established in this academic year.

ECEGAPS is a new organization that aims to provide a social and professional community for electrical and computer engineering graduate students and post-docs. We also hope to be able to act as a medium for the members' social, cultural, academic, and professional objectives. We have been able to assist in new graduate student orientation, hold weekly social events, and have collaborated with other organizations across UCLA Engineering for recruiting events to this date. We hope to continue with these activities and offer new ones in the future.

If you would like additional information or want to become a sponsor for ECEGAPS, please email **eechair@seas.ucla.edu** for details.

— Sina Basir-Kazeruni

2016-2017 Outstanding Student and Teaching Awards

Sina Basir-Kazeruni, recipient of the *Henry Samueli Excellence in Teaching Award* for a graduate course, with Professor Dana Watson and Chair Greg Pottie.

Pranshu Bansal *(left)*, recipient of the *Henry Samueli Excellence in Teaching Award* for a design course, with Professor William Kaiser and Chair Greg Pottie.

Ahmed Hareedy received the *Henry Samueli Excellence in Teaching Award* for a lecture course, with Chair Greg Pottie.

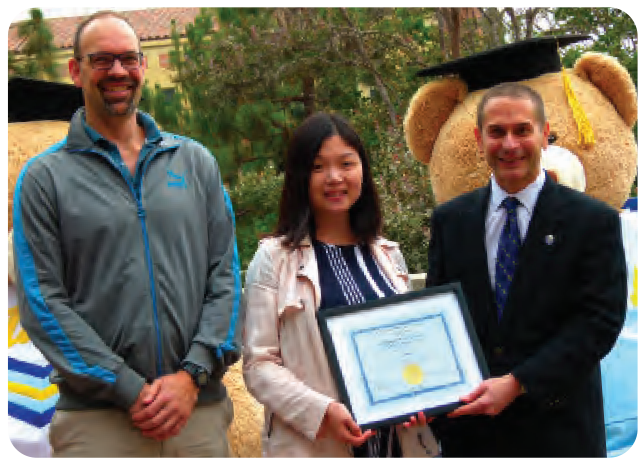
Chi-Yo Tsai, *Outstanding Bachelor of Science and Christina Huang Memorial Prize* recipient, with Chair Greg Pottie.

Vignesh Manohar, *Outstanding Master's Thesis Award in Physical & Wave Electronics*, with Professors Rahmat-Samii and Pottie.

Mohammadhasan Fayazi, *Outstanding Master's Thesis Award in C&ES.* Seyed Armin Razavi received the award on his behalf.

Jaclyn Yanguen, **Fernando Pacheco**, **Lindsay Light**, **Ali Jishi**, and **Kevin Balke**, recipients of the *Engineering Achievement Awards for Student Welfare*, next to Chair Greg Pottie. Not pictured: **Nicholas Ryan Adair**, **Bryan John Emerson**, **Justine Capati Figuerres**, **Kari Garcia**, **Emil Shallon**, and **Alex Sin**.

Frederic Sala, Outstanding Ph.D. Dissertation in Signals & Systems, *Algorithms and Coding Techniques for Reliable Data Management and Storage*, with advisor Professor Lara Dolecek and Chair Greg Pottie.



Luyao Xu, Outstanding Ph.D. Dissertation in Physical & Wave Electronics, *Terahertz Metasurface Quantum Cascade Laser*, with advisor Professor Benjamin Williams and Chair Greg Pottie.

Sameed Hameed, Outstanding Ph.D. Dissertation in Circuits & Embedded Systems, *Design and Analysis of Programmable Receiver Front-Ends Based on LPTV Circuits*, with advisor Prof. Pamarti and Chair Greg Pottie.

UCLA IEEE Student Chapter

UCLA Institute of Electrical and Electronics Engineers (IEEE) is one of the largest engineering-focused clubs at UCLA. In addition to our corporate infosessions, workshops, and events aimed to help students in career building and professionalism, UCLA IEEE is known for the challenging, educational, and fun projects that allow true hands-on experience outside the classroom.

The Open Project Space program focuses on teaching the fundamentals of hands-on electrical engineering. Our computer science-focused analogy, C3 (Code, Create, Compete), allows computer science majors to join in on the fun with their own customized projects. For advanced students who want a challenging robotics experience, the Micromouse and Natcar projects are oportunities to build something crazy. Students are also free to come up with independent projects.

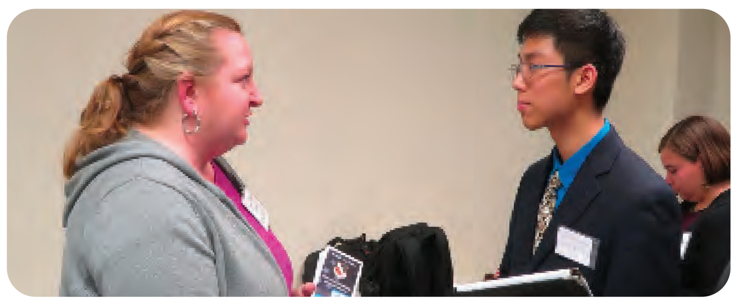
IEEE hosts several large events open to the wider engineering community, such as an annual fair showcasing local startups, as well as an all-day professional development workshop.

UCLA HKN

The UCLA Iota Gamma Chapter of Eta Kappa Nu (HKN) is a unique organization dedicated to encouraging and recognizing excellence through a balance of scholarship, service, leadership, and character in the electrical and computer engineering fields. The club provides valuable service by conducting training sessions in MATLAB and Lab View. HKN members also provide tutoring services.

The club hosts lunches with professors, technical talks, and visiting companies. With the IEEE, it co-hosts the annual ECE Department Town Hall where concerns of students are discussed with the faculty.

The Iota Gamma Chapter of HKN continues to see impressive student involvement under the guidance of its advisor, Professor Benjamin Williams, with over 200 members currently participating in the student club.

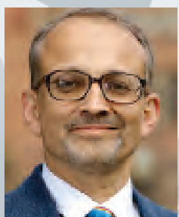


UCLA Electric Vehicle Project

The UCLA Electric Vehicle (EV) is a project-oriented student club with a simple mission statement: to build UCLA's first ever fully electric vehicle. EV is a member of the Bruin Racing team within the MAE Department, but with an emphasis on Electrical and Computer Engineering. As one of the only clubs to be advised by two departments, EV provides students with a unique interdisciplinary experience spanning all stages of building a car—from chassis design to electric motor control.

For new recruits, EV conducts Freshmen Seminars, a series of lectures and mini projects designed to equip members with practical hardware engineering skills. Additionally, EV hosts resume building days and career workshops throughout the year in conjunction with those held by IEEE. EV also does its best to introduce members to cutting edge car technologies such as autonomous driving and vehicle-to-vehicle communication. The ultimate goal for EV is to develop a custom brushless DC motor controller and enter the vehicle to race in the Shell Eco-Marathon competition. With a little over 20 active members split into multiple design teams, EV offers a unique environment akin to a start-up for passionate students to work on an electric vehicle.

Members of National Academies




Professor Asad A. Abidi
National Academy of Engineering, 2007
for his contributions to the development of MOS integrated circuits for RF Communications.

Distinguished Adj. Professor Asad M. Madni
National Academy of Engineering, 2011
National Academy of Inventors, 2015
Former President, COO and CTO of BEI Technologies Inc. He is a Fellow of the NAI, IEEE, IEE, IET, AAAS, NYAS, SAE, IAE and AIAA.



Professor Mau-Chung Frank Chang
National Academy of Engineering, 2008
National Academy of Inventors, 2015, for his contributions in development and commercialization of III-V-based heterojunction bipolar transistors (HBTs) and field-effective transistors (FETs) for RF wireless communications.

Adjunct Professor Dan Goebel
National Academy of Engineering, 2015
Senior Research Scientist, Jet Propulsion Laboratory. For contributions to low-temperature plasma sources for thin-film manufacturing, plasma materials interactions, and electric propulsion.

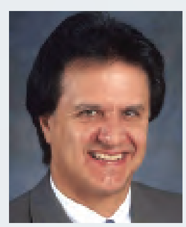
Professor Tatsuo Itoh
National Academy of Engineering, 2003
National Academy of Inventors, 2013
"for seminal contributions in advancing electromagnetic engineering for microwave and wireless components, circuits, and systems."



Professor Chandrashekhar Joshi
National Academy of Engineering, 2014
Founder of the experimental field of plasma accelerators. He is also a Fellow of the American Physical Society, IEEE and the Institute of Physics.

Professor Kuo-Nan Liou
National Academy of Engineering,1999
Director of the Joint Institute for Regional Earth System Science and Engineering. Nobel Peace Prize, 2007, shared with Intergovernmental Panel on Climate Change.

Professor Stanley Osher
National Academy of Sciences, 2005
for "major contributions to algorithm development and applications in level set methods, high-resolution shock capturing methods, and PDE-based methods in imaging science."

Professor C. Kumar Patel
National Academy of Sciences, 1974
National Academy of Inventors, 2012
Made numerous contributions in gas lasers, nonlinear optics, molecular-spectroscopy, pollution detection and laser surgery.

Distinguished Professor Yahya Rahmat-Samii
National Academy of Engineering, 2008
for his contributions to the design and measurement of reflector and hand-held device antennas.

New Members of National Academy of Engineering

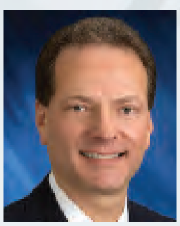
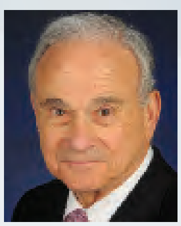
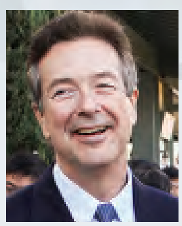
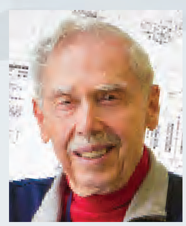
NATIONAL ACADEMY OF ENGINEERING

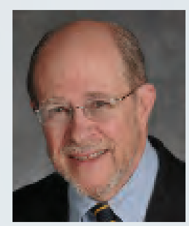
Distinguished Chancellor's Professor Jason Cong

National Academy of Engineering in 2017, for pioneering contributions to application-specific programmable logic via innovations in field-programmable gate array synthesis. Professor Cong's area of interests are computer system architecture, energy-efficient computing, reconfigurable computing, electronic design automation, fault-tolerant design of VLSI systems, design for nanotechnologies, design and analysis of algorithms. He is the Director of the Center for Customizable Domain-Specific Computing and the VLSI Architecture, Synthesis, and Technology (VAST) Laboratory.

Professor Behzad Razavi

National Academy of Engineering in 2017, for contributions to low-power broadband communication circuits. Professor Razavi's areas of interest are Analog, RF, mixed-signal integrated circuit design, dual-standard RF transceivers, phase-locked systems and frequency synthesizers, A/D and D/A converters, high-speed data communication circuits. He is the director of the Communication Circuits Laboratory.



Professor Henry Samueli

National Academy of Engineering, 2003

for his "pioneering contributions to academic research and technology entrepreneurship in the broadband communications system-on-a-chip industry."

Recipient of the Marconi Prize, 2012, and UCLA Medal, 2010.

Professor Jason Speyer

National Academy of Engineering, 2005

for "the development and application of advanced techniques for optimal navigation and control of a wide range of aerospace vehicles."

Professor Dwight Streit

National Academy of Engineering, 2001

for "contributions to the development and production of heterojunction transistors and circuits."

Distinguished Professor Emeritus Gabor Temes

National Academy of Engineering, 2015

for his "contributions to analog signal processing and engineering education."

Professor Eli Yablonovitch

National Academy of Engineering, 2003

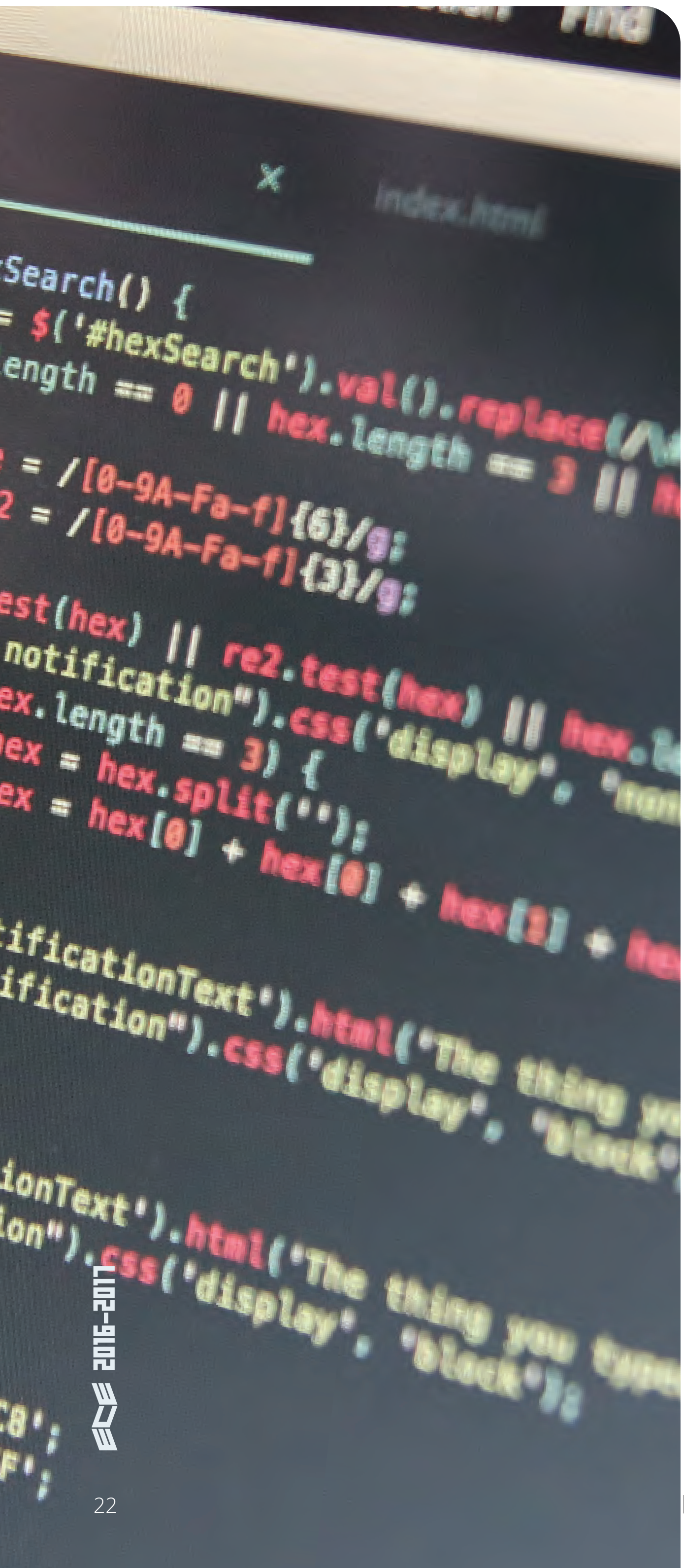
National Academy of Sciences, 2003

Professor Alan N. Willson, Jr.

National Academy of Engineering, 2014

for "contributions to the theory and applications of digital signal processing."

Circuits & Embedded Systems



Faculty Pictured

Jason Cong
Puneet Gupta
Ankur Mehta

Also

Lei He

Design Automation for Computer Systems

We investigate methodologies and algorithms for the design of complex systems, including circuits and semiconductor technologies, robots, cyberphysical and energy systems, and the Internet of Things.

The effects of nanoscale semiconductor technologies span the entire hardware-software stack, and we investigate how technology changes in devices as well as semiconductor fabrication influence design (especially layout). We study digital, mixed-signal, and FPGA-based configurable integrated circuits in the context of emerging challenges of energy efficiency, security, reliability, variability and manufacturability. We also explore architecture and system software techniques to mitigate variability and reliability challenges of increasingly unpredictable circuit fabric.

Robotics and cyberphysical systems is a rapidly growing field that spans a range of engineering disciplines. We study how such a broadly scoped area can be rigorously codified, inventing representations for the formal definition and analysis of interdisciplinary design. With an eye towards manufacturability, we investigate methods of encapsulating engineering principles and distilling them into design automation algorithms.

Our research seeks to dramatically reduce cost, increase proliferation, and promote the democratization of design of hardware-software systems.

Energy-Efficient Digital Architectures and Circuits

We are focusing on digital integrated circuit optimization in the power-area-performance space, its application to emerging health care and communication algorithms, and the investigation of design principles with post-CMOS devices. This includes advanced communication algorithms such as those found in future cognitive radios and new advances in biomedical applications.

Faculty Pictured

Danijela Cabric
Babak Daneshrad
Subramanian S. Iyer
Dejan Markovic

Also

Jason Cong
Lei He
Ali Sayed
C.-K. Ken Yang

Emeriti Faculty

Rajeev Jain
Gabor Temes
Jack Willis
Alan Willson

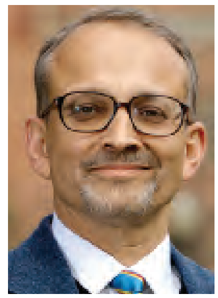
Neuroengineering

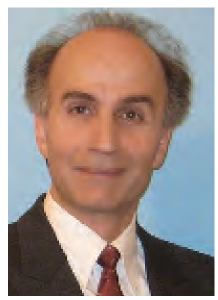
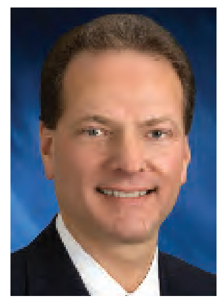
We address challenges that limit our ability to obtain information as well as our ability to process it in incredibly small and low-power form factors, to advance technology for science, therapy and global health. Our work brings together low-power data processing, biosignal interfaces, communication, and energy aspects to push the limits of biosignal transducer systems, where the energy, size and processing requirements are often orders of magnitude more challenging than in conventional applications. The cross-disciplinary nature of our work naturally stimulates collaboration across the areas of signal processing, circuits and systems, and devices, as well as interactions at the biological and engineering levels.

Jason Cong
Dejan Markovic

Communication Circuits

We develop integrated circuits for data communications spanning the entire gamut of data rates, ranges, and communication media: from wireless to wired, from PCB traces to plastic waveguides, from intra-chip to long haul links, from cellular to space communications, from VHF to terahertz frequencies, and from low power links to multi-Gb/s links. Our focus is on CMOS electronics and our faculty members are pioneers in this field. We address the fundamental challenges posed by noise, device nonlinearity, and variability in affecting communications in harsh environments, employing theoretical analysis, creative circuit design, and algorithmic digital correction techniques. The recent focus has been on enabling true software defined radios, mm-wave and terahertz applications.




Faculty Pictured

Asad Abidi
Wentai Liu
Sudhakar Pamarti
Behzad Razavi
Henry Samueli
C.-K. Ken Yang

Also

M.-C. Frank Chang
Y. Ethan Wang

Sensor Information Acquisition, Processing, and Applications

Sensory information is foundational to modern electronic computing systems across a myriad of application domains such as health, energy, environment, and communications. Our research is developing innovative technologies for the entire waveform-to-decision pathway through which sensor information flows, often in real-time, distributed and resource-constrained settings. In work, we are developing (i) high-sensitivity and low-power transducers and A/D converters for capturing and digitizing sensor signals; (ii) high-performance hardware-software platforms for processing sensor data; and (iii) efficient algorithms and protocols for processing sensor data to derive rich inferences under power, processing, and security constraints in networked settings. Moreover, the results of our research are being applied to real systems in various applications.

Faculty

Chi On Chui

Also

Sam Emaminejad
William Kaiser
Aydogan Ozcan
Gregory Pottie
Mani Srivastava

Embedded and Mobile Computing and Cyber-Physical Systems

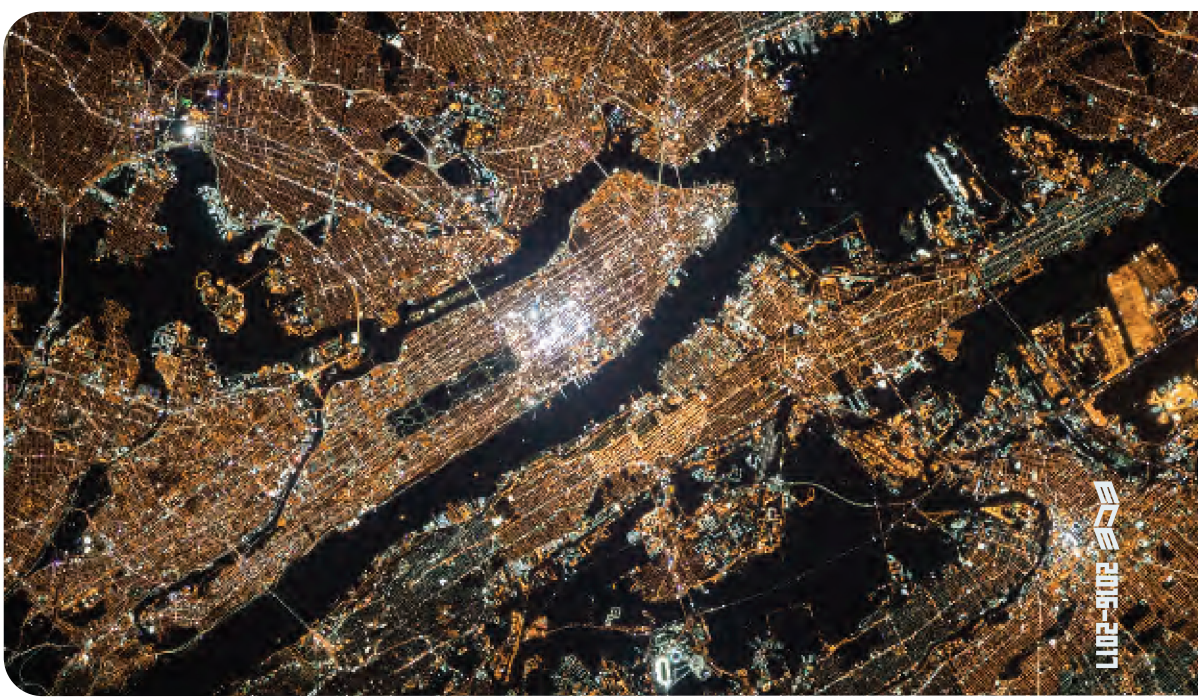
We focus on foundational hardware and software technologies and architectures for computing and communication capabilities necessary for emerging embedded, mobile, and cyber-physical systems. Such systems are found in emerging application domains of critical socio-economic importance, such as robotics, mobile health, sustainable built environments, smart electrical grids, smart water networks, and transportation systems. Our research addresses the fundamental capabilities needed by these systems such as energy efficiency, real-time performance, location awareness, precise time synchronization, adaptation to variations, secure operations, etc., and also develops novel implementation methods spanning the entire system stack from application and operating system software down to the processor, datapath, memory, and I/O hardware.

Faculty Pictured
Lei He
William Kaiser
Majid Sarrafzadeh
Mani Srivastava




Also
Suhas Diggavi
Puneet Gupta
Ankur Mehta
Paulo Tabuada

Circuits and Embedded Systems Adjunct Faculty
Hooman Darabi
Shervin Moloudi

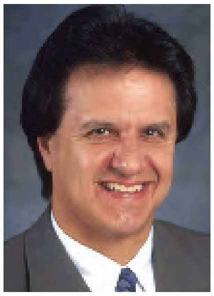
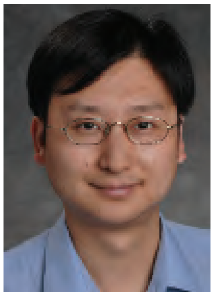
Physical & Wave Electronics

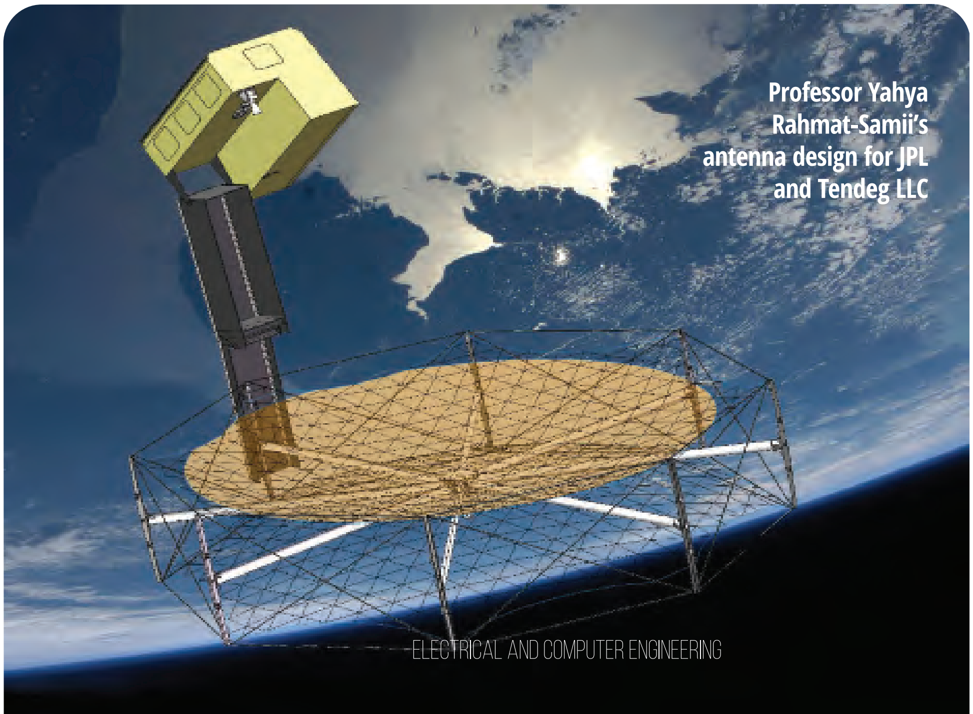
Electromagnetics

Electromagnetics embodies all aspects of science and engineering topics stemming from Maxwell's equations, describing the behavior of electric and magnetic fields and their interactions with electric charges and currents. The science of electromagnetics underlies nearly all modern electric, computation, and communications technology. Both our coursework and research address theoretical, computational, optimization, design and measurement aspects of electromagnetic devices for a variety of applications, including wireless communications, satellite, space and ground systems, medical and sensor applications, multi-function antennas and metamaterials in frequencies ranging from microwaves and millimeter waves to terahertz.







Professor Yahya Rahmat-Samii's antenna design for JPL and Tendeg LLC

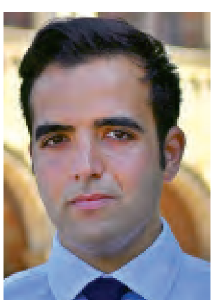
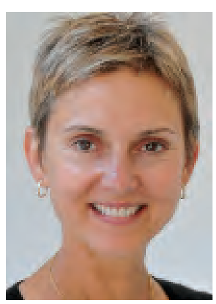
Faculty Pictured
Aydin Babakhani
M.-C. Frank Chang
Tatsuo Itoh
Kuo-Nan Liou
Yahya Rahmat-Samii
Y. Ethan Wang

Also
Robert Candler
Mona Jarrahi
Warren Mori
Aydogan Ozcan
Benjamin Williams
Chee Wei Wong

Emeritus Faculty
Frederick Schott

Nanoelectronics, Devices and Heterogeneous Integration

In the area of nanoelectronics and solid-state devices, UCLA is at the forefront of research. Major research efforts are ongoing for the synthesis and design of advanced materials, such as two-dimensional semiconductors, topological insulators, and magnetic oxides — both their fundamental properties and their applications to ultra-scaled logic and memory devices. We also have extensive activities in the design and fabrication of ultra-scaled devices on both silicon and compound semiconductors, such as power and RF transistors, spin-based switches and memory elements, tunnel FETs, and other novel devices that are suitable for applications that go beyond conventional scaling. Another major thrust is the development of neuromorphic (i.e., brain-inspired) devices and nanosystems for computation and information processing. Nanoelectronic devices are under investigation for use as sensors for compact biomedical sensing tools. This area also includes the development of Micro- and Nano-Electromechanical Systems (MEMS and NEMS). In addition, we investigate new methods of interconnecting heterogeneous devices for a more holistic interpretation of Moore's law. Many of these research activities take place in collaboration with other research groups, both within and outside ECE, on circuit/system/device co-design and co-optimization. The nanoelectronics research in the department is supported by advanced commercial simulation tools for device analysis, a state-of-the-art nano-fabrication facility, and device characterization equipment with capability from DC to over 100GHz.




Faculty Pictured

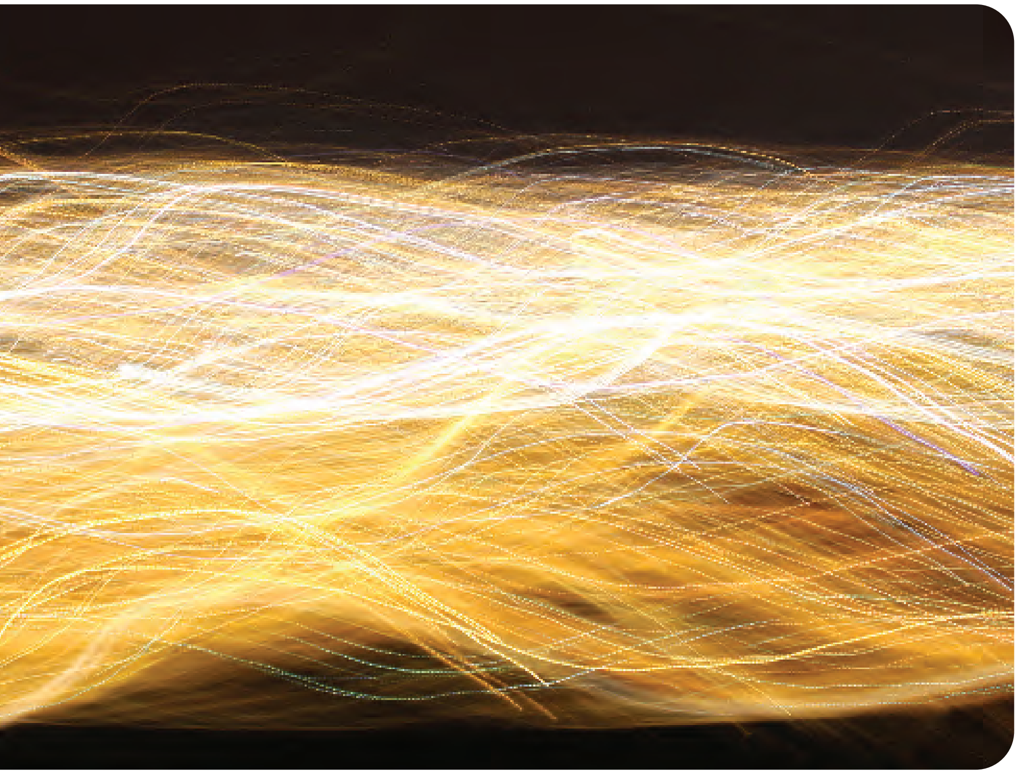
Robert Candler
Sam Emaminejad
Diana Huffaker
Mona Jarrahi
Dwight Streit
Kang Wang
Chee Wei Wong
Jason C. S. Woo

Also

Aydin Babakhani
Chi On Chui
Subramanian S. Iyer

Emeriti Faculty

Fred G. Allen
Harold Fetterman
Dee Son Pan
King-Ning Tu
Chand Viswanathan



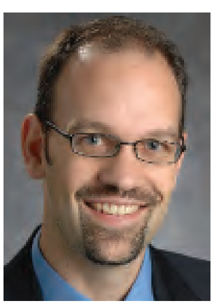
Photonics

Photonics deals with the generation, detection, and manipulation of light — specifically how it can be harnessed to provide useful functions. For example, nearly all of the information on the internet is transported by encoding it onto signals of infrared light carried on optical fibers. Many unknown materials can be identified by studying how light interacts with them (i.e., by scattering, absorbing, phase shifting, or polarizing some incident photons). The name "photonics" emphasizes the importance of quantum mechanical properties of light and its interaction with matter. Many topics in photonics research involve development and/or use of lasers. Our research program encompasses topics such as how light interacts both with matter on the nanoscale and in plasmas, as well as new ways to generate, detect, and control light in underdeveloped spectral regions. Applications under investigation include the diverse topics of solar energy generation, lensless microscopy for cell-phone based telemedicine, high energy laser wakefield particle accelerators, ultra-high frame rate imaging, silicon photonics, biomedical imaging, and use of stabilized lasers for ultra-high precision measurements — just to name a few.









Faculty Pictured

Katsushi Arisaka
Warren Grundfest
Bahram Jalali
Jia-Ming Liu
Aydogan Ozcan
Oscar Stafsudd
Benjamin Williams

Also

Diana Huffaker
Mona Jarrahi
Chan Joshi
Chee Wei Wong

Emeritus Faculty

Harold Fetterman

Plasma Electronics

Plasma Electronics covers a wide spectrum of activities that include electro-dynamics of charged particles in external fields, non-linear optics of plasmas, high energy-density plasmas, laser-plasma interactions, basic plasma behavior, computer simulations of laboratory and space plasmas and fusion plasmas. The applications being studied are plasma-based charged particle accelerators, free electron lasers, other plasma-based radiation sources, laser-fusion, astrophysical plasmas, plasma propulsion, gas lasers and plasmas for lighting. There are opportunities to do experimental, theoretical and computer simulations research in all these areas. Close collaborations exist with national laboratories at Livermore and SLAC and UCLA's state-of-the art laboratories including the Neptune Laboratory that houses the world's most powerful CO_2 laser. The research group also has the Dawson II computational cluster for research on inertial confinement fusion, plasma accelerators and astrophysical plasmas.

Faculty Pictured

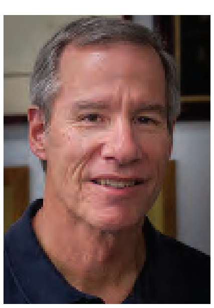
Chan Joshi
Warren Mori

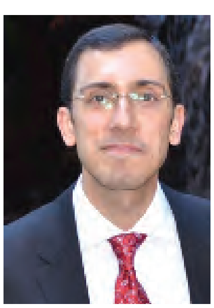
Emeritus Faculty

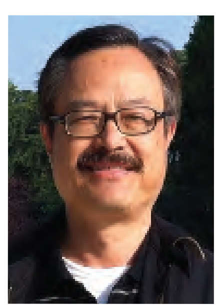
Francis F. Chen

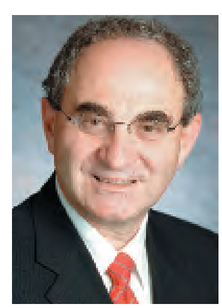
Physical & Wave Electronic Adjunct Faculty

Dan Goebel
Pedram Khalili
Asad M. Madni
Yi-Chi Shih
Zachary Taylor
Eli Yablonovitch

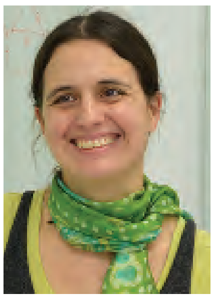


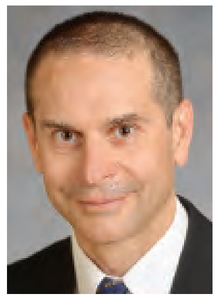
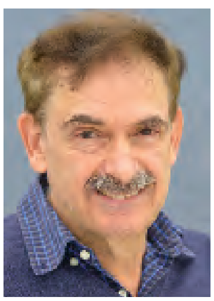
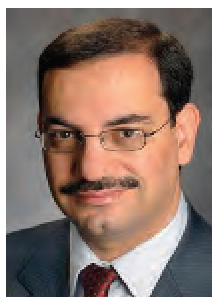






Signals & Systems




Faculty Pictured

Christina Fragouli
Ali Mosleh
Gregory Pottie
Izhak Rubin
Ali H. Sayed
Lixia Zhang

Also

Danijela Cabric
Babak Daneshrad
Suhas Diggavi
Asad M. Madni
Ankur Mehta
Mihaela van der Schaar
Mani Srivastava
Paulo Tabuada
John Villasenor
Richard D. Wesel

Communications and Networking

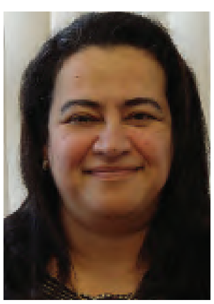
UCLA has a tradition in Communications and Networking research. For example, the first Internet packets were sent from UCLA and the Viterbi Algorithm was developed here. In an increasingly interconnected and online world, our research encompasses computer networks, social networks, wireless networks, on-chip networks and biological networks. Our work spans from fundamental questions in communications networking, autonomous vehicular networks, multimedia telecommunications, coding theory, algorithms, resource allocation, game theory, network economics, information theory and security to applications in mobile computing, sensors and embedded systems, distributed control systems, media distribution, green computing, intelligent cities, smart grid, cognitive radios, emergency networks and mobile health.

Emeriti Faculty

Nhan Levan
Paul K.C. Wang
Donald Wiberg
Kung Yao ***(below)***

Signal Processing and Machine Learning

We rely on signals to interact with the physical and virtual world. A challenge today is how to collect, analyze, store, and process large data in an efficient and scalable manner. Our signal processing research targets the inference, visualization, representation, and learning of a broad spectrum of signals related to media (including speech, video and social media networks), sensors (for medical, military, space, process control or environmental applications), communications and control networks (such as wireless and utility networks), and adaptive arrays (such as acoustic and radar). This applies to problems ranging in scale from the microscopic to Big Data. Research contributes to disciplines descended from both EE and CS roots, such as machine learning, statistical signal processing, stochastic modeling, graphical models, information theory, adaptation and learning algorithms, inference over networks, distributed signal processing, data analysis and distributed optimization.



Faculty Pictured
Abeer Alwan
Lara Dolecek
Jonathan Kao
Stefano Soatto
Paulo Tabuada
John Villasenor

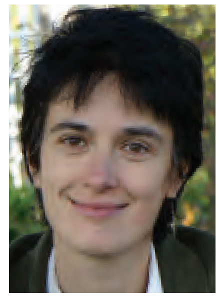
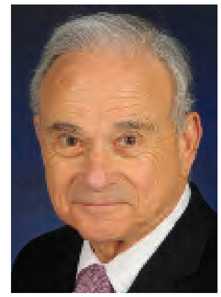
Also
Danijela Cabric
Allie Fletcher
Lei He
Suhas Diggavi
William Kaiser
Asad M. Madni
Gregory Pottie
Vwani Roychowdhury
Ali H. Sayed
Mihaela van der Schaar
Mani Srivastava
Lieven Vandenberghe

Emeriti Faculty
Kung Yao
Alan Willson (above)

Control and Decision Systems

Control and decision systems research aims to develop the mathematical principles explaining how complex systems can behave correctly in uncertain environments. One key program strength is in cyber-physical systems that network together collaborating computational elements with physical elements. We work in improving their functionality, autonomy, and adaptability, analyze their performance and ensure their secure operation. Applications include autonomous vehicles, transportation networks, medical systems, robotics coordination, smart buildings and smart power grids. Another strength is in the intersection of economics with engineering.



Faculty Pictured

Panagiotis Christofides
Alan Laub
Mihaela van der Schaar
Jason L. Speyer

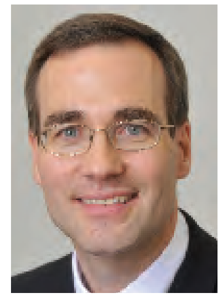
Also

Suhas Diggavi
Ankur Mehta
Ali Mosleh
Izhak Rubin
Ali H. Sayed
Paulo Tabuada
Lieven Vandenberghe




Signals & Systems Adjunct Faculty

Ezio Biglieri
Dariush Divsalar
Allie Fletcher
Asad M. Madni
Ingrid Verbauwhede



Faculty Pictured
Suhas Diggavi
Stanley Osher
Vwani Roychowdhury
Lieven Vandenberghe
Richard D. Wesel

Also
Lara Dolecek
Christina Fragouli
Alan Laub
Ankur Mehta
Izhak Rubin
Ali H. Sayed
Mihaela van de Schaar
Paulo Tabuada

Emeritus Faculty
Stephen Jacobsen

Information, Computation and Optimization Theory

Information theory research develops the fundamental limits of compression, encryption, and channel coding of data in a variety of networks, storage media and communications systems. Application areas include new types of storage systems and more efficient and secure networks. Computation theory research characterizes the fundamental complexity of problems and the types of algorithms that can be used to solve them efficiently and/or approximately. Optimization theory research studies how minimizing cost functions inherent in problems spanning from economics to broad swaths of engineering can be formulated and efficiently solved.

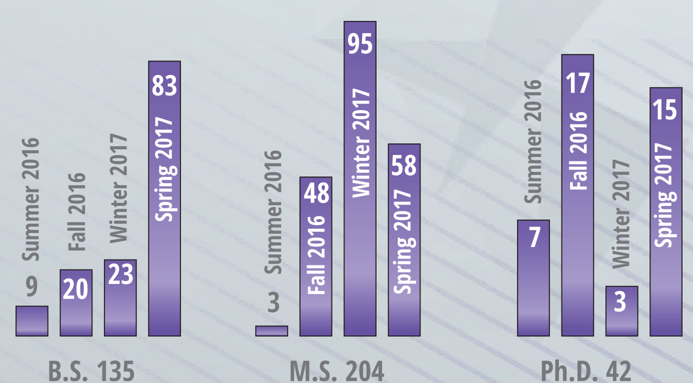
The Electrical and Computer Engineering Department

Research Centers

The Electrical and Computer Engineering Department contributes to the following Research Centers:

- Anderson School of Management – Easton Technology Management Center (ETMC)
- California NanoSystems Institute (CNSI)
- Center for Design-Enabled Nanofabrication (C-DEN)
- Center for Development of Emerging Data Storage Systems (CoDES2)
- Center for Domain-Specific Computing (CDSC)
- Center for Engineering Economics, Learning and Networks (CEELN)
- Center for Heterogeneous Integration and Performance Scaling (CHIPS)
- Center for High Frequency Electronics (CHFE)
- Center of Excellence for Green Nanotechnologies (CEGN)
- Function Accelerated nanoMaterial Engineering (FAME)
- Institute for Digital Research and Education (IDRE)
- Institute for Pure and Applied Mathematics (IPAM)
- Institute for Technology Advancement (ITA)
- Integrated Systems Nanofabrication Clean Room (ISNCR)
- Interconnected & Integrated Bioelectronics Lab (I^2BL)
- Joint Institute for Regional Earth System Science and Engineering (JIFRESSE)
- Nanoelectronics Research Facility (NRF)
- Public Safety Network Systems (PSNS)
- Translational Applications for Nanoscale Multiferroic Systems (TANMS)
- Variability Expedition, Variability-Aware Software for Efficient Computing with Nanoscale Devices (VE)
- Water Technology Research Center (WaTer)
- Western Institute for Nanoelectronics (WIN)
- Wireless Health Institute (WHI)

Graduate Students Admitted



Faculty and Staff

Ladder Faculty	47
Courtesy Appointments	13
Emeriti Faculty	13
Adjunct Faculty	11
Lecturers	14
Post-Doc	45
Staff	42

Recognitions

Society Fellows	47
NAE Members	16
NAS Members	3
National Academy of Inventors	4
Marconi Prize	1

Graduate Student Fellowships

Department Fellowships	1,512,753
Non-resident Tuition for Teaching Assistants	327,210
Dissertation Year Fellowship	254,279
Broadcom Fellowship	187,245
Dean's GSR Support	168,750
Samueli Fellowship	71,546
Mediatek Fellowship	57,125
Faculty Unrestricted Fellowships	56,607
Qualcomm Fellowship	55,308
Guru Krupa Fellowship	51,629
Ph.D. Preliminary Exam Top Score Fellowships	49,747
Microsoft Fellowship	44,324
Graduate Opportunity Fellowship	36,405
Living Spring Fellowship	35,951
Dean's Fellowship & Camp Funds	29,000
GEM	22,142
HSSEAS MS Online TA NRT Support	15,102
Kalosworks	10,123
Cyber Medical Imaging	10,000
IEEE	10,000
Living Rocks Fellowship	5,440
Graduate Dean's Scholar	5,000
Raytheon Fellowship	2,163
Intel Fellowship	2,163
TOTAL	*$3,020,012*

Undergraduate Students

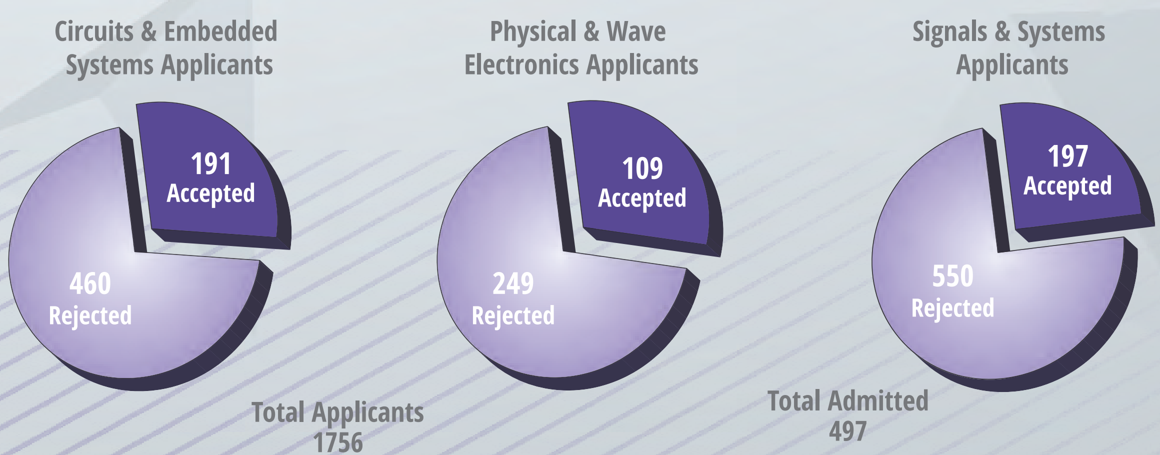
Students Enrolled	598	
Applicants	1477	
Admitted	329	
New Students Enrolled	121	
Average Incoming GPA	4.46	*(weighted)*
	3.92	*(unweighted)*

Graduate Students

Students Enrolled	557
Applicants	1964
Admitted	459
New Students Enrolled	185
Median Incoming GPA	3.78

Graduate Applicants for Fall 2016

Graduate Students Admitted



Alumnae Advisory Committee

Thanks to the leadership of Professor Abeer Alwan and our accomplished alumnae, a new and vibrant organization has been created. The UCLA ECE Alumnae Advisory Committee aims to educate and enable female students of all ages to pursue academic and career opportunities in electrical and computer engineering. The key mission of the committee is to unite alumnae to support one another, and to foster a community of outreach and development for girls interested in science and technology, from the time they start elementary school through university and beyond.

Grace Evita King
Co-Chair
Attorney with Squire Patton Boggs

Ani Garabedian
Co-Chair
Northrop Grumman, Communications Systems Engineering

Kelsey Curtis
Chair of the Subcommittee on Student Mentoring
Engineer at Infineon Technologies

Melissa Erickson
Chair of the Bay Area Chapter
Sr. Technical Program Manager at Amazon Lab126

Sonia Hingorany
Chair of the Seattle Chapter
Amazon, North American Transportation Group

Caitlin Gomez
Co-Chair of the Subcommittee on K-12 Outreach
Radiation Oncologist

Jenny Ji
Co-Chair of the Subcommittee on K-12 Outreach
Captain at US Air Force

Guadalupe Zaragoza
Co-Chair Subcommittee for Alumnae Networking
Principal Systems Engineer at Raytheon

Judy Gilmore
Co-Chair Subcommittee for Alumnae Networking
Systems Engineer at Advanced Concept Technologies

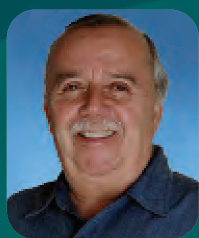
Alumni Advisory Board

Heba A. Armand
Group Product Manager, Avery Consumer Products

Phil Bangayan
Director of Marketing NBC/Universal

The Alumni Advisory Board provides advice to assist the UCLA Electrical and Computer Engineering Department in enhancing its leadership role in education and research. The Board organizes the Distinguished Alumni Lecture Program focusing on insights from their fields of expertise or offering guidance on topics of practical interest, such as launching and funding a technology-based business and protecting intellectual property rights.

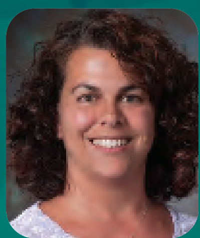
Sharon Black
GPS & Navigation Systems Director Raytheon



Leonard Bonilla
Retired Program Manager Raytheon

Grace King
Attorney with Squire Patton Boggs

David Doami
Director Programs Northrop Grumman



Ani Garabedian
Northrop Grumman Communications Systems Engineering

Erica Skoglund
Texas Instruments HP Worldwide Account Manager

Ray (Ramon) Gomez
Retired Sr. Technical Director Broadcom

Dan Goebel
Adjunct Professor and Senior Research Scientist at Jet Propulsion Laboratory

Leo Szeto
Founder Codeate, Inc.

William Goodin
UCLA Engineering Retired

Robert Green
Attorney Lewis Roca Rothgerber Christie, LLP

Asad M. Madni
ECE AAB Chair President, COO and CTO (Retired) BEI Technologies, Inc.

Electrical and Computer Engineering Partnerships

The Electrical and Computer Engineering Department has been forging new partnerships with industry over the past year with its Electrical Engineering Partnerships (EEP) program. The UCLA EEP tightly couples academic education and research with the needs of industry by working directly with partners in nurturing our pipelines of talent both at the undergraduate and graduate levels. We enhance visibility to our student activities with industry through open houses and research reviews, and we propagate industry needs with our students through hands-on projects, material in courses, industry lecturers, and collaborative research opportunities. EEP also provides linkages for partners to access UCLA's state-of-the-art facilities. These activities are possible through the support of our partners. More details are available at the EEP website: ***http://www.ee.ucla.edu/industry***

THE AEROSPACE CORPORATION

BROADCOM

MEDIATEK

NORTHROP GRUMMAN

QUALCOMM

Raytheon

MediaTek Fellowships 2016-2017

MEDIATEK

UCLA Electrical and Computer Engineering and **The MediaTek Foundation** are proud to announce the new 2016-2017 MediaTek Fellows. The Selection Committee selected two students based on proposed research projects which showed the most innovative technology research concept. The MediaTek Fellowship provides full graduate student researcher support, including non-resident tuition for one academic year and a possible paid summer internship. Founded in 1997, MediaTek is a pioneering fabless semiconductor company and a market leader in cutting-edge systems on a chip. MediaTek created the world's first octa-core smartphone platform with LTE; and the CorePilot technology released the full power of multi-core mobile processors. MediaTek is committed to making technology more accessible and affordable for everyone. This year's Fellows are:

Sameed Hameed
Highly linear and programmable receiver front-ends
Advisor: Sudhakar Pamarti

Jiacheng Pan
A highly efficient wireless power transfer system that is immune to distance and load variations
Advisor: Asad Abidi

UCLA HSSEAS Electrical and Computer Engineering

Administration

Gregory J. Pottie	Department Chair
Abeer Alwan	Vice-Chair, Undergraduate Affairs
Mona Jarrahi	Vice-Chair, Graduate Affairs
C.-K. Ken Yang	Vice-Chair, Industry Relations
Puneet Gupta	Vice-Chair, Computer Engineering

Area Directors

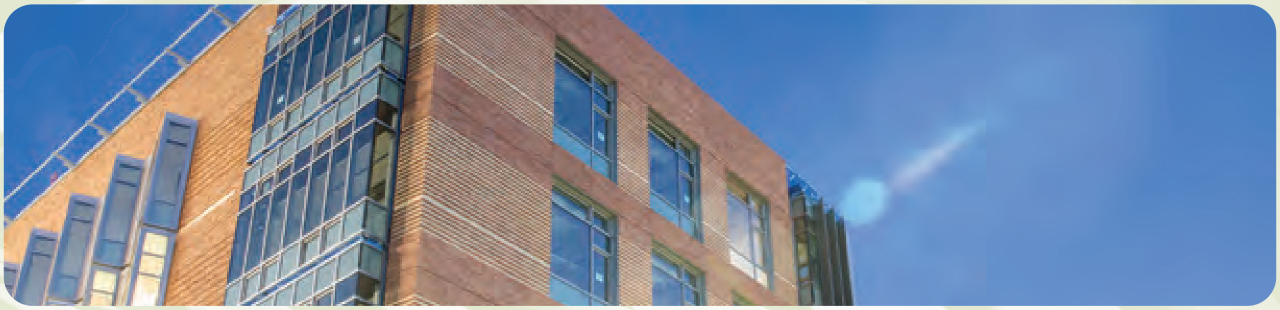
Danijela Cabric	Director, Circuits and Embedded Systems
Christina Fragouli	Director, Signals and Systems
Y. Ethan Wang	Director,Physical and Wave Electronics

ABET Committee

Abeer Alwan	Professor and Vice-Chair, Undergraduate Affairs
Asad M. Madni	Alumni Advisory Board Chair
Gregory J. Pottie	Department Chair
C.-K. Ken Yang	Professor and Vice-Chair, Industry Relations

Center Directors and Committee Chairs

Robert N. Candler	Director, Nano-Electronics Research Facility
Suhas Diggavi	Chair, Recruitment Committee
Warren Mori	Chair, Tenure Committee
Sudhakar Pamarti	Chair, Non-Tenure Committee
Lieven Vandenberghe	Chair, Courses and Curriculum Committee
Y. Ethan Wang	Director, Center for High-Frequency Electronics



Annual Report 2016-2017

Editors/Coordinators

Gregory J. Pottie	Professor & Chair
Jacquelyn T. Trang	Chief Administrative Officer

Design

Mauricio Feldman-Abe	Designer

Writers

Matthew Chin, UCLA Engineering Communications Manager
Associate Professor Aydin Babakhani
Sina Basir-Kazeruni, Ph.D. Student
Professor Rob Candler
William Goodin, UCLA Engineering, Retired
Professor Dan Goebel
Professor Subramanian S. Iyer
Professor Mona Jarrahi
Professor Asad M. Madni
Professor Aydogan Ozcan
Professor Gregory J. Pottie
Professor Kang Wang
Professor Y. Ethan Wang

UCLA Engineering
HENRY SAMUELI SCHOOL OF
ENGINEERING AND APPLIED SCIENCE
Birthplace of the Internet

Electrical and Computer Engineering Department
University of California
Los Angeles, CA 90095
www.ee.ucla.edu