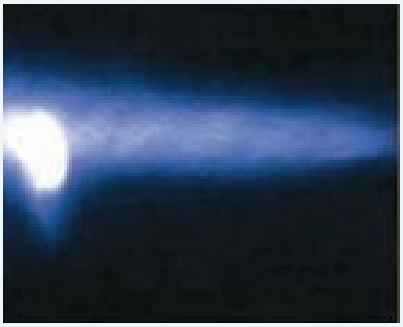
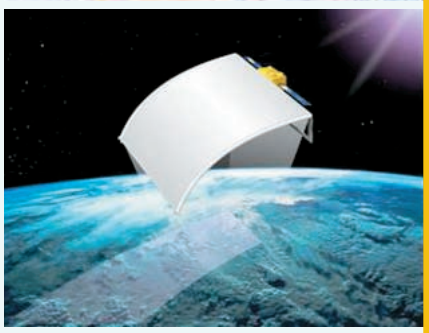
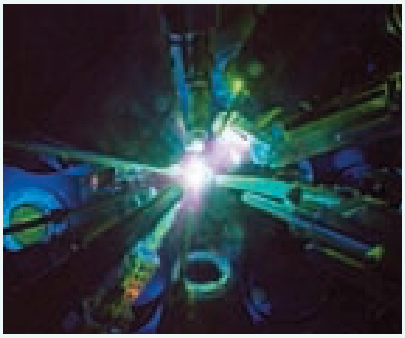
Henry Samueli School of Engineering and Applied Science

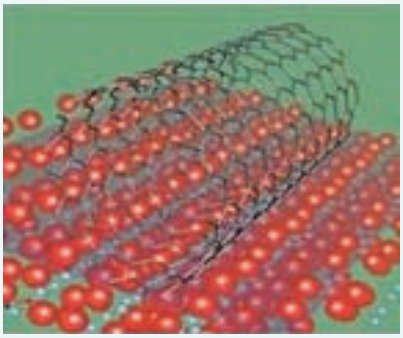
UCLA

Electrical Engineering









2007-2008

Select Highlights


Professors M. C. Frank Chang and Yahya Rahmat-Samii are elected to the **National Academy of Engineering**.

Professor Asad Abidi receives the 2008 **IEEE Donald O. Pederson Award** in Solid-State Circuits.




Professors Abeer Alwan, Diana Huffaker, Jia-Ming Liu and Mani Srivastava are elevated to the grade of **IEEE Fellow**.

Associate Professor Diana Huffaker receives the $3M **National Security Science and Engineering Faculty Fellowship** award from the Department of Defense.

Assistant Professor Benjamin Williams receives the **Young Faculty Award** from DARPA.

DARPA awards a major multi-year multi-million dollar contract to support research by Professor Jason Woo and collaborators on revolutionary switching devices.

Professor Behzad Razavi publishes a new textbook entitled *Fundamentals of Microelectronics*, Wiley, 2008.

Professor Ali H. Sayed publishes a new textbook entitled *Adaptive Filters*, Wiley, 2008.

The department gratefully acknowledges the help and support of:
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Bradley International Hall

Annual Report 2007-2008

We are honored to share with you the achievements of our department during the 2007-2008 academic year. Several of our faculty members received outstanding recognitions for their scholarly achievements.

Professors M. C. Frank Chang and Yahya Rahmat-Samii were both inducted to the **National Academy of Engineering** (NAE), the highest professional lifetime distinction accorded to American engineers. Their induction to the NAE follows last year's induction of Professor Asad Abidi. Over the last 5 years, our department has had 6 faculty members elected to the National Academy of Engineering, a testament to the growing recognition and strengths of our program.

Professor Abidi was also recognized with the prestigious **2008 IEEE Donald O. Pederson Award in Solid-State Circuits**. In addition, four of our faculty members were elevated to the grade of **IEEE Fellow**: Professor Abeer Alwan for contributions to speech perception and production modeling and their applications, Professor Diana Huffaker for the development of optoelectronic materials and processing, Professor Jia-Ming Liu for contributions to the control and applications of nonlinear dynamics of lasers, and Professor Mani Srivastava for contributions to energy-aware wireless communications and sensor networking. Furthermore, Professor Diana Huffaker was selected to receive the prestigious **National Security Science and Engineering Faculty Fellow** Award from the DoD. Up to $3 million of research support is granted to each NSSEFF Fellow for up to five years.

Our faculty members continue to be actively engaged in **major multi-disciplinary research centers and institutes** such as the Center for Embedded Networked Sensing (CENS), the California NanoSystems Institute (CNSI), the Center on Functional Engineered Nano Architectonics (FENA), and the Western Institute of Nanoelectronics (WIN). During 2007-2008, the US Department of Defense (DoD) provided $2.9M to support the Center for Nanoscience Innovation for Defense (CNID), and the US Defense Advanced Research Agency (DARPA) awarded a multi-year contract totaling close to $7.2M to a team of Electrical Engineering researchers led by Professor Jason Woo to develop a revolutionary switching device.

We continue to recruit aggressively in an effort to expand our reach and strengthen collaborations with other areas and particularly the **medical sciences**. Over the last 3 years, nine assistant and one associate professors were hired in areas ranging from bio-photonics to medical imaging, lasers, circuits, nano and semiconductor devices, cognitive radios, and embedded control systems. The infusion of a relatively large number of bright and dynamic junior faculty members is helping the department stretch to new areas with confidence and optimism for the future.

Our **industry relations** program is being reinvigorated. Stronger ties are being cemented with industry through focused research collaborations, regular student internships, mutual visits, and annual research reviews. Several companies are active members of our Industry Affiliates Program including The Aerospace Corporation, Boeing, Broadcom, Hitachi, Lockheed Martin, Northrop Grumman, Qualcomm, Raytheon, Samsung, Sony, Synplicity, Toshiba, and Viasat. During the 2008 Annual Research Review meeting, over 40 companies sent representatives to interact with our faculty and students.

We are proud of the accomplishments of our department. We are also grateful to our staff and supporters for their continued and valued contributions to our program.

Ali H. Sayed
Department Chairman

Overview

Faculty and Staff

Ladder Faculty	43.5 FTEs
Courtesy Appointments	9
Emeriti Faculty	11
Adjunct Faculty	14
Lecturers	27
Staff	45

Recognitions

Society Fellows	32
NAE Members	7
NAS Members	2
National Medal of Science	1

Nanolab

Research Facilities

Laboratories and Research Groups: 32

Space: 102,669 square feet

Department Contributes to 9 Research Centers:

California NanoSystems Institute (CNSI)

Center for Embedded Networking Sensing (CENS)

Center for High Frequency Electronics (CHFE)

Center for Systems, Dynamics and Controls (SyDyC)

Flight Systems Research Center

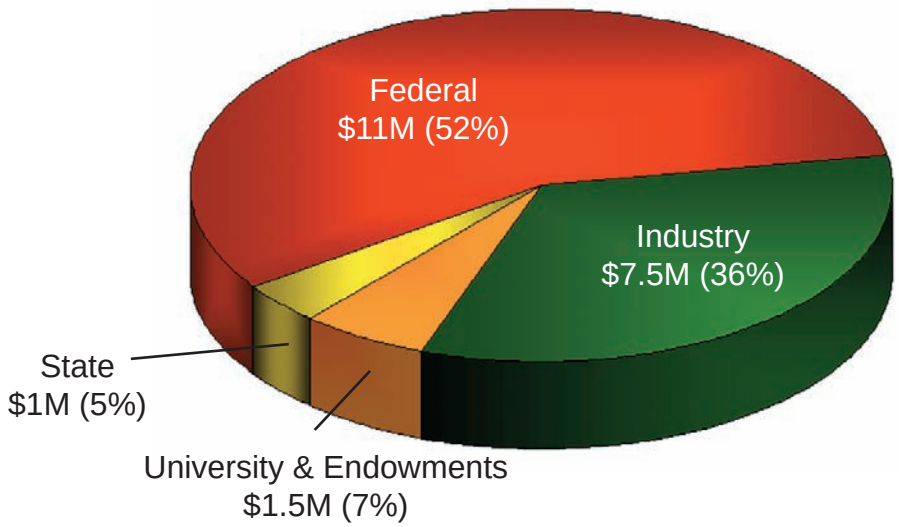
Functional Engineered Nano Architectonics Focus Center (FENA)

Institute for Cell Mimetic Space Exploration (CMISE)

Nanoelectronics Research Center (NRC)

Western Institute of Nanotechnology (WIN)

Research Funding 2007-2008 ($21M)



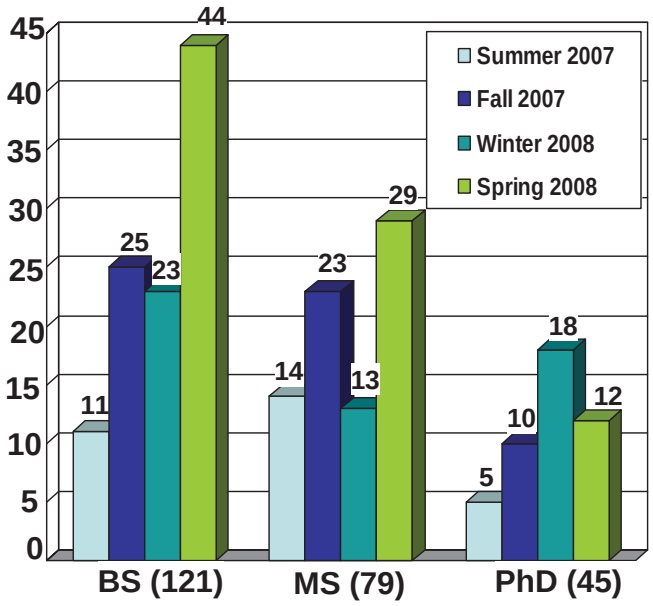
Undergraduate Students

Students Enrolled	563
Applicants	983
New Students Enrolled	216
Average Freshman GPA	3.83

Graduate Students

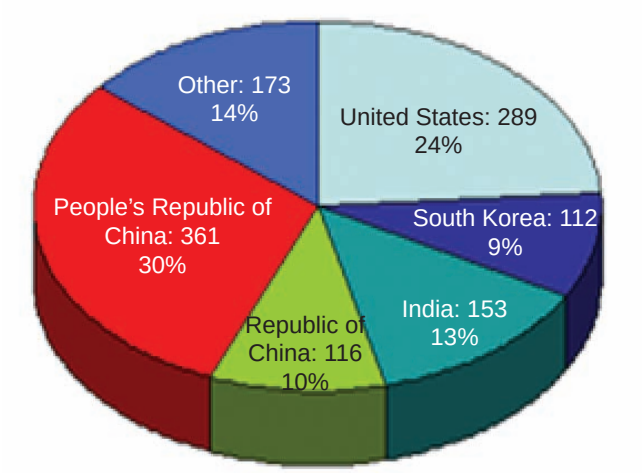
Students Enrolled	342
Applicants	1204
New Students Enrolled	72
Average Incoming GPA	3.71

EE Degrees Conferred 2007-2008



Graduate Applicants for Fall 2007

Countries with over 5% of 1204 total applicants

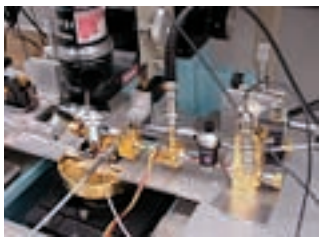


Fellowships Received by Electrical Engineering Graduate Students		
Full Fellowships	$	419,550.00
Non-Resident Tuition Support for Teaching Assistants	$	217,186.00
Dean's GSR Support	$	187,555.00
Partial Fellowships	$	160,095.00
One-Quarter Merit Fellowships	$	120,045.00
Henry Samueli Fellowships	$	113,678.00
Faculty Unrestricted Fellowships	$	86,202.00
Chancellor's Prize	$	83,911.00
Dissertation Year Fellowships	$	55,023.00
NSF Graduate Fellowship	$	38,968.00
Camp Fellowship	$	30,000.00
Dean's Fellowship	$	25,000.00
Borgstrom Fellowship	$	10,000.00
Raytheon Fellowship	$	8,967.00
Rockwell Fellowship	$	8,967.00
Conference Travel Funds	$	1,200.00
Phi Beta Kappa Alumni Fellowship	$	500.00
TOTAL	**$**	**1,628,847.00**

Faculty Highlight: Professor M.C. Frank Chang

Professor M.C. Frank Chang

Electrical Engineering Professor Mau-Chung Frank Chang has been elected to the **National Academy of Engineering** (NAE) for his seminal contributions to the discovery, development and commercialization of III-V based Heterojunction Bipolar Transistors (HBTs) and Field Effect Transistors (FETs) technologies for RF/wireless communications. His pioneering work in realizing mass-produced GaAs HBT power amplifiers with high efficiency and high linearity has enabled modern wireless communications that require sophisticated modulations for high data rates and high output power to cover a wide area with minimum battery-power consumption.



On-Wafer VCO Test Set developed at JPL

Prior to joining UCLA in 1997, Professor Chang was the Assistant Director and Department Manager of the High Speed Electronics Laboratory at Rockwell Science Center, Thousand Oaks, California. While at Rockwell, he took what was once considered theoretical heterojunction technology and enabled reliable, readily manufactured devices and integrated circuits critical to today's cellular GSM and WCDMA telephones and wireless area networks (WLANs).

His current research at UCLA is focused on the design and development of RF and mixed signal CMOS System-on-Chips (SOCs) for next generation communication, computation and imaging system applications. He invented the multiband, reconfigurable RF-Interconnects, based on FDMA and CDMA multiple access algorithms, for ChipMulti-Processor (CMP) inter-core

CMOS VCO designed by Prof. M.C. Frank Chang's group at UCLA, fabricated in 90nm process

CMOS Voltage Controlled Oscillator, measured with a subharmonic mixer and driven with a 166 GHz local oscillator. The mixing frequency is (f_{VCO} - 2*f_{LO})=f_{IF}, or f_{VCO}-2*(166 GHz)= 8.2 GHz, yielding f_{VCO}= 324 GHz!

communications and simultaneous and bi-directional chip-to-chip CPU-to-Memory communications. He also pioneered the development of multi-gigabit/sec ADC, DAC and DDFS in both GaAs HBTs and Si CMOS technologies for both commercial and defense systems; the millimeter-wave reconfigurable radio transceiver (60-100GHz) based on transformer-folded-cascode (Origami) high-linearity circuit topology; and the low phase noise CMOS VCO (FOM<-200dB/Hz) by using digitally controlled on-chip artificial dielectric (DiCAD).

Among other awards, Professor Chang received the IEEE David Sarnoff Award (IEEE-wide Technical Field Award) in 2006, Taiwan's most prestigious Pan Wen-Yuan Foundation Research Award in 2008, and the Best Paper Award from the IEEE Computer Society at the 2008 International Symposium on High Performance Computer Architecture (HPCA). He has authored over 270 technical papers and holds 20 U.S. patents.

Powell Library Reference Room

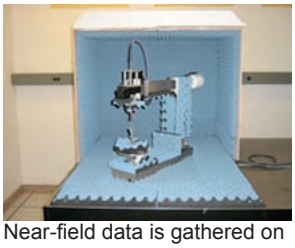
Faculty Highlight: Professor Yahya Rahmat-Samii

Professor Y. Rahmat-Samii

Electrical Engineering Professor Yahya Rahmat-Samii, holder of the Northrop Grumman Chair in Electromagnetics and former department chair, has been elected to the **National Academy of Engineering** (NAE) for his fundamental contributions to innovative design, optimization and measurement of reflector antennas and antennas for handheld communication devices.

"The diversification of our research, including advanced computational techniques, nature-inspired optimization algorithms and modern measurement techniques, has really helped design and develop new antennas with ample industrial and scientific applications", Rahmat-Samii points out . "Many of these designs are currently used in cell phones, planetary spacecraft looking for the origin of the universe and life, earth observation satellites, satellite dishes, etc."

Rahmat-Samii has been an electrical engineering faculty member at the UCLA Henry Samueli School of Engineering and Applied Science since 1988. His research contributions cover diverse areas of electromagnetics, antennas, satellite and ground station antennas, personal communications antennas including human interactions, meta-material, modern antenna measurement techniques, numerical and optimization techniques, diffraction and scattering, etc (www.antlab.ee.ucla.edu).



Near-field data is gathered on concentric rings that are then processed to produce far-field patterns.

"Having benefited from my experience at JPL/NASA, my work has always had the common denominator of evolving from novel abstract concepts to advanced simulation demonstrations and finally prototyping for real life applications. We have extensively published the results of our work allowing others to judge them and also hopefully benefit from them. I am proud of our accomplishments," Rahmat-Samii says.

Rahmat-Samii has received numerous other recognitions for his work notably the 2007 IEEE Chen-To Tai Distinguished Educator Award, the 2005 URSI Booker Gold Medal, and the IEEE Third Millennium Medal.

Murphy Scultpture Garden

National Security Science and Engineering Faculty Fellow

Professor Diana Huffaker

UCLA Electrical Engineering Associate Professor Diana Huffaker has been selected to receive the prestigious National Security Science and Engineering Faculty Fellow (NSSEFF) Award from the Department of Defense (DoD).

NSSEFF provides grants to top-tier researchers from U.S. universities to conduct long-term, unclassified, basic research of strategic importance to DoD. Up to $3 million of research support is granted to each NSSEFF Fellow for up to five years.

Professor Huffaker received the award in recognition of her project entitled "Exploring Dissimilar and Nanomaterials Integration as a Platform for New Medium and Long Wave Infrared Device Functionality."

Professor Huffaker joined the Electrical Engineering Department in 2007. She was elevated to the rank of IEEE Fellow in November 2007 for "the development of optoelectronic materials and processing." Her research interests cover nanodot-based optoelectronic devices including III-V/Si photonics, lasers, single-photon emitters, III-V nanotransistors, solar cells and electronic characterization of biomaterials. Her current research projects focus on device development, crystal growth (MBE and MOCVD) and characterization of patterned and self-assembled quantum dots in compound III-(As, P, N, Sb), modeling of self-assembled processes along with electronic characterization of biomaterials.

Four Faculty Members Elevated to IEEE Fellow Grade

Four Electrical Engineering faculty members have been elevated to the grade of IEEE Fellow. This is a reflection of their accomplishments and contributions to the profession:

- Professor Abeer Alwan "*for contributions to speech perception and production modeling and their applications*."
- Professor Diana Huffaker "*for the development of optoelectronic materials and processing*."
- Professor Jia-Ming Liu "*for contributions to the control and applications of nonlinear dynamics of lasers*."
- Professor Mani Srivastava "*for contributions to energy-aware wireless communications and sensor networking*."

A. Alwan

D. Huffaker

J.M. Liu

M. Srivastava

Electronic Design and Manufacturing Automation Laboratory

Bridging VLSI Design and Manufacturing

Professor Puneet Gupta, Director

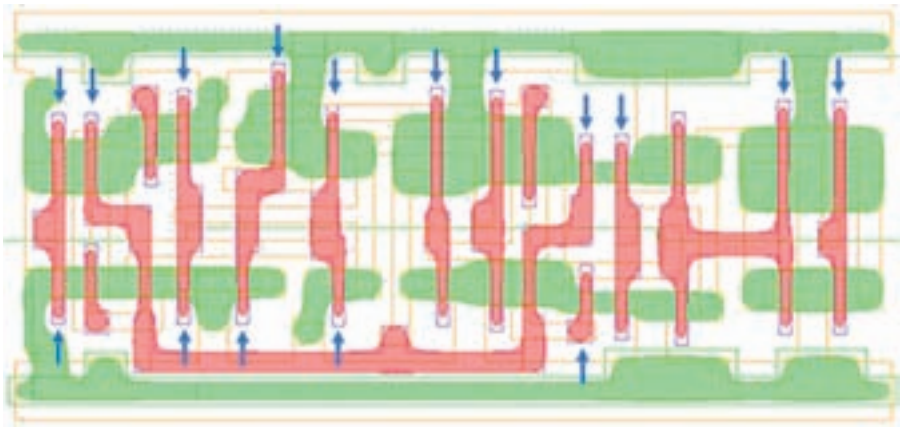
The semiconductor industry is at an interesting - and scary - juncture. Design and manufacturing NRE (nonrecurring engineering) costs for a state-of-the-art chip can reach several tens of millions of dollars; this makes the transition to newer processes economically infeasible for low- to medium-volume IC products. Silicon manufacturers have struggled to keep pace with the ever-present drive to smaller process geometries. Foundry capital costs have risen from $6M in 1970 to over $2B for a modern 300mm facility; at the same time, process windows have shrunk steadily, implying greater manufacturing risks. Scaling of physical dimensions faster than the optical wavelengths or equipment tolerances used in the manufacturing line has led to increased process variability. This in turn has led to unpredictable design, unpredictable manufacturing, and low yields. The Moore's Law scaling promise of integration and cost reduction is clearly at risk today.

As a result of the above trends, future power, performance and cost improvements cannot come from the manufacturing process alone; they depend significantly on design automation technology. Such "equivalent scaling" improvements - perhaps as much as one full technology generation - must come from new synergies between various "silos" of the design to manufacturing flow. Dr. Gupta's research has been spurred by four key challenges.

- High cost of design
- High cost of manufacturing
- Low manufacturing yield
- Disconnect between design and process

Dr. Gupta's group is addressing these challenges by developing novel bidirectional data flows between design and manufacturing; these flows reduce cost and power, and increase yield and performance.

The semiconductor industry is likely to see several radical changes in the fabrication and device technologies in the next decade. On patterning front, these include adoption of one or more of candidate next-generation lithography (NGL) techniques such as double patterning, spacer lithography, nano-imprint, character projection and extreme ultraviolet (EUV). On device front, these include high-k metal gate, strained silicon, multi-gate FETs, carbon-nanotube FETs, single electron transistors, etc. Each of these technologies requires enormous research investment before they can see any adoption. Moreover, they have strong (and interesting!) implications for circuit and layout methodologies and algorithms in the design. Dr. Gupta's research group currently focuses on enabling and evaluating next generation technology from a design perspective. Further, instead of treating the manufacturing process as a black-box that needs to be only modeled, we are investigating algorithmic methods of manufacturing process optimization driven by design analyses that can significantly speed up parametric yield ramp and improve product characteristics.



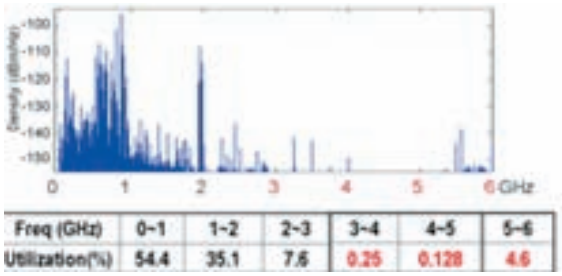
Example of simulated wafer shape of a flip-flop in a 65nm process. Notice the lithographic imperfections.

Cognitive Reconfigurable Systems (CORES) Laboratory

Cognitive Radio Technology

Professor Danijela Cabric, Director

A major shift in wireless communications is now emerging with the development of cognitive radios, which attempt to share spectrum in a fundamentally new way. These radios are addressing the fact that spectrum is actually poorly utilized in many bands, in spite of the increasing demand for wireless connectivity (Figure 1). On a conceptual level, cognitive radio networks sense the spectral environment and adapt transmission parameters to dynamically reuse available spectrum. This is not just a hypothetical concept, there is actual evidence that the FCC supports this technology and is currently working on the rules for cognitive radio operation in licensed TV bands. The FCC's interest also extends to higher frequencies, where the spectrum utilization is even lower. The realization of this vision could open up to 100 GHz of spectrum and a new frontier of opportunities for radio designers and wireless application developers. However, the novelty of this approach requires new mechanisms for using radio frequencies through sharing rather than fixed allocations.



Freq (GHz)	0~1	1~2	2~3	3~4	4~5	5~6
Utilization(%)	54.4	35.1	7.6	0.25	0.128	4.6

Figure 1. Measurements of spectrum utilization in 0-6GHz band

Professor Cabric is exploring fundamental questions in cognitive radio system design by bridging the theoretical and practical aspects of the physical and network layers. She proposed a cognitive radio system architecture that presents the basis for integration of core cognitive radio functions, spectrum sensing and adaptive transmission over wide bandwidths, with protocols and control channels for cognitive network management. One of her main contributions is the understanding of implementation issues and limitations of spectrum sensing, which is considered the key enabling functionality for cognitive radios. Spectrum sensing presents a major challenge as it requires detection of very weak signals of different types in a minimum time with high reliability (Figure 2). The most comprehensive approach is to address

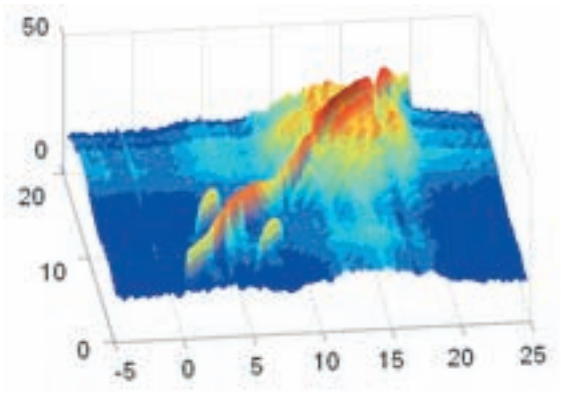


Figure 2. Feature detection based spectrum sensing

it as a cross-layer design problem that involves radio RF front-end, digital signal processing and networking solutions. Professor Cabric created a spectrum sensing design framework for analysis of techniques across these three layers and selection of the optimal system level sensing design based on performance and implementation cost. Her work involves a closed loop research approach connecting theoretical analysis and development of new algorithms with their implementation and experimental verification. This system level design perspective is needed to show the feasibility of cognitive radio technology.

Looking forward, Professor Cabric believes that use of spatial dimension and multiple antennas presents many new opportunities in cognitive radio spectrum sharing. Resolving signals in angular domain allows selective processing of interference sources and localization of wireless nodes. From the higher layer perspective, she is interested in exploring how spectrum sensing in both temporal and spatial dimensions can provide better physical layer security and network management.

The Optoelectronics Circuits & Systems Laboratory

Findings Could Help Resolve Mystery of Monster Ocean Waves

Professor Bahram Jalali, Director

Maritime folklore tells tales of giant "rogue waves" that can appear and disappear without warning in the open ocean. Also known as "freak waves," these ominous monsters have been described by mariners for ages and have even appeared prominently in many legendary literary works, from the Odyssey to Robinson Crusoe.

Once dismissed by scientists as fanciful sailors' stories, recent observations have shown that they are a real phenomenon, capable of destroying even large modern ships. Nevertheless, these mysterious waves have continued to elude researchers.

Now, Electrical Engineering researchers Daniel Solli, Claus Ropers, Prakash Koonath, and Bahram Jalali at the UCLA Henry Samueli School of Engineering and Applied Science have created and captured rogue waves. In their experiments, they have discovered optical rogue waves—freak, brief pulses of intense light analogous to the infamous oceanic monsters—propagating through optical fiber. Their findings appear in the Dec. 2007 issue of the journal *Nature*.

"Optical rogue waves bear a close connection to their oceanic cousins," said lead investigator Daniel Solli, a UCLA Engineering researcher. "Optical experiments may help to resolve the mystery of oceanic rogue waves, which are very difficult to study directly."

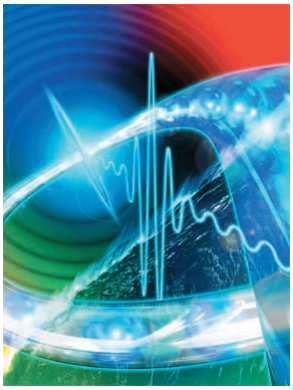
It is thought that rogue waves are a nonlinear, perhaps chaotic, phenomenon, able to develop suddenly from seemingly innocuous normal waves. While the study of rogue waves has focused on oceanic systems and water-based models, light waves traveling in optical fibers obey very similar mathematics to water waves traveling in the open ocean, making it easier to study them in a laboratory environment.

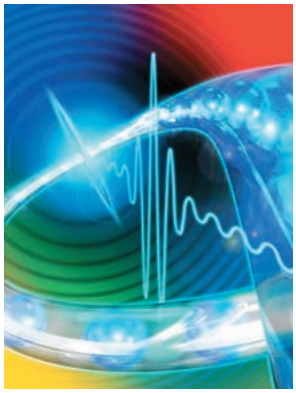
Still, detecting a rogue wave is extremely difficult. The wave is a solitary event that occurs rarely, and, to make matters worse, the timing of its occurrence is entirely random. But using a novel detection method they developed, the UCLA research group was able to capture optical rogue waves and measure their statistical properties.

They found that, similar to freak waves in the ocean, optical rogue waves obey "L-shaped" or "fat-tail" statistics—a type of distribution in which extreme events are rare, but much more probable than predicted by conventional (so-called normal or Gaussian) statistics.

Bahram Jalali, UCLA professor of electrical engineering, points out that similar behavior also occurs in other systems: "For example, rare but extreme events, popularly known as 'black swans,' also occur in financial markets with spectacular consequences. Our observations may help develop mathematical models that can identify the conditions that lead to such events."

The research was funded by the Defense Advanced Research Projects Agency (DARPA), the central research and development organization for the U.S. Department of Defense.



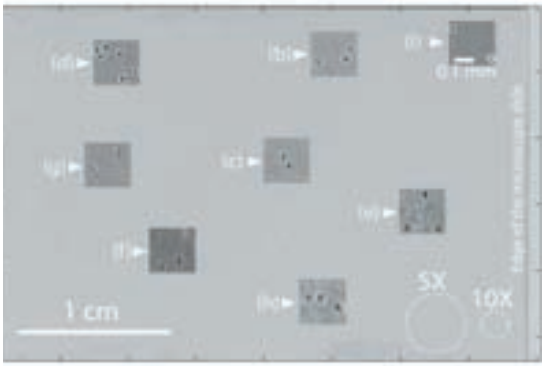


The Bio- and Nano-Photonics Laboratory

Bringing Shadow to Point-of-Care

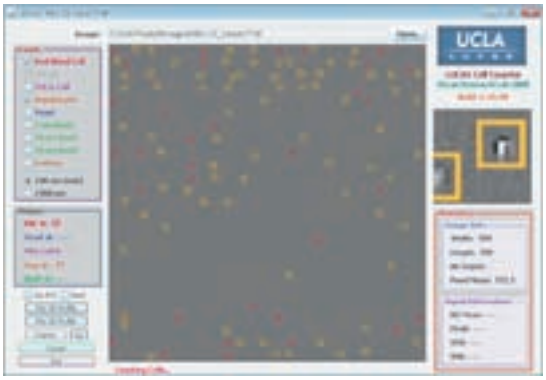
Professor Aydogan Ozcan, Director

There are many medical diagnostic applications that need a cost-effective, compact, and high-throughput technology to accurately analyze bodily fluids such as blood, urine, saliva or other heterogeneous cell solutions derived from various different tissues such as the bone marrow, adipose tissue, etc. One such application is the point-of-care monitoring of *HIV* patients, where a compact and inexpensive technology that can measure the count of $CD4^+$ T cells from whole blood samples is needed. Another example is the detection and isolation of e.g., *circulating tumor cells* from blood.



Fibroblasts detected within less than a second over an area of ~10 cm^2. No lenses or microscope objectives were used. A regular microscope, using e.g., a 5X objective-lens, could only detect an area shown within the dashed circle above. *This implies the field-of-view is improved ~100 fold.*

All of these medical applications, and many others, require a high-throughput platform that can specifically identify the characteristic signatures of target cells/bacteria among millions of other micro-objects. And therefore, the above described set of applications has some common challenges: (1) The target cells (or bacteria) that need to be counted exist within a heterogeneous solution at very low concentrations which makes it quite difficult to *specifically* and *accurately* detect their characteristic signatures; (2) Currently existing methods are costly to operate (such as flow-cytometry), labor-intensive, low throughput or bulky, i.e., can not be easily miniaturized for point-of-care applications.



High-throughput imaging of a heterogeneous solution over a field-of-view ~10 cm^2 is shown. The location and count of each red blood cell and hepatocyte are automatically detected by our cutom developed decision algorithm.

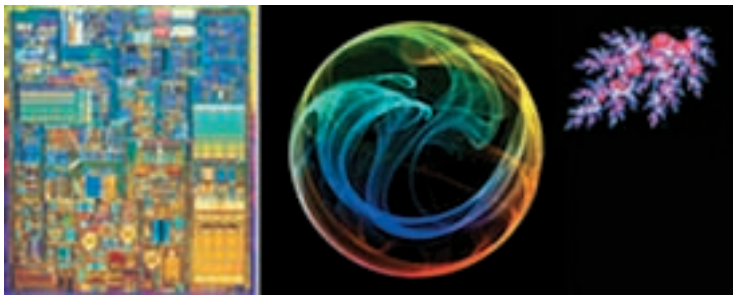
Professor Aydogan Ozcan's Research Group works on a novel solution that is based on photonics to offer a complete solution to the above discussed challenges *bringing a comforting shadow to the point-of-care*. What is quite unique about the approach of his group is that it can rapidly monitor and characterize various different cells/bacteria within a heterogeneous solution with a record high speed of ~5 ml/sec (or >50,000 cells/sec) without the need for any lenses, microscope-objectives or any mechanical scanning. Furthermore, this powerful imaging platform offers an extremely compact device volume that can eventually be *integrated within a regular wireless cell-phone, permitting sample loading through e.g., a disposable microfluidic chip.*

Two DARPA Projects: STEEP and CERA

Revolutionary Switching Devices

Professor Jason Woo

The U.S. Defense Advanced Research Projects Agency (DARPA) has awarded a multi-year contract totaling close to $7.2M to a team of researchers led by UCLA Electrical Engineering Professor Jason Woo to develop a revolutionary switching device. DARPA is an agency of the U.S. Department of Defense responsible for the development of new technology for use by the military. The project is in collaboration with Jazz Semiconductor and other UCLA Engineering faculty including Electrical Engineering Professors Chi On Chui, Frank Chang, and Kang Wang and Materials Science Professor Ya-Hong Xie.



The basic device is an asymmetric tunnel transistor that takes advantage of band-to-band tunneling to produce characteristics that include ultra steep sub-threshold slope and Ion/Ioff ratio up to 1000x better than state-of-the-art MOSFET devices. Such devices will be designed to be scalable, have the ability to dramatically reduce circuit power consumption in both the on and off states, and be capable of integration with future SOI wafer based advanced CMOS nodes. Professor Woo is leading two DARPA projects: STEEP and CERA.

STEEP Project

The STEEP project studies a revolutionary new switching device to replace conventional MOSFET in critical defense (and commercial) low power high performance applications. This new switching device fully exploits novel processes and device design to maximize terminal currents and minimize leakage, and it has the potential to overcome the shortfalls of deeply scaled MOSFETs.

In this project, the researchers are proposing a novel Tunnel-Source transistor. For such a device, the ON-OFF state is controlled by modulating the states available for the band-to-band tunneling. This provides an extremely sharp ON-OFF transition. In addition, when the device is ON, the channel resistance is lower than conventional MOSFETs. The researchers will examine the device design/optimization and the process technology to fabricate these high performance/low power transistors. The research will also investigate the impact of the Tunnel-Source transistor in low power systems.

CERA Project

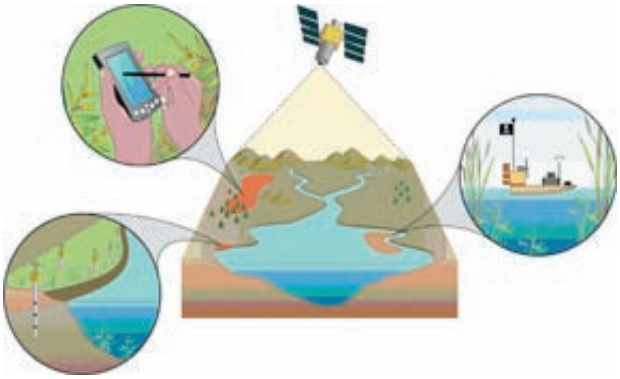
The CERA project focuses on a revolutionary new RF transistor with graphene channel to replace conventional MOSFET in critical defense (and commercial) high performance RF applications. The new graphene channel transistors, while compatible with mainstream CMOS platform, fully exploit novel processes and device design to maximize the RF performance at very low supply voltage, thus enabling low power RF circuits that can be integrated with VLSI digital CMOS. In this project, the UCLA researchers will investigate the impact of the GraOI transistors in RF circuits, and will research novel low power RF circuit design methodologies and architectures that can take full advantages of these novel devices.

Center for Embedded Networked Sensing (CENS)

CENS is a major research enterprise focused on developing wireless sensing systems and applying this revolutionary technology to critical scientific and societal pursuits. In the same way that the development of the Internet transformed our ability to communicate, the ever decreasing size and cost of computing components is setting the stage for detection, processing, and communication technology to be embedded throughout the physical world and, thereby, fostering both a deeper understanding of the natural and built environment and, ultimately, enhancing our ability to design and control these complex systems.

By investigating fundamental properties of embedded networked sensing systems, developing new technologies, and exploring novel scientific and educational applications, CENS is a world leader in unleashing the tremendous potential these systems hold.

The center is a multidisciplinary collaboration among faculty, staff, and students from a wide spectrum of fields including Computer Science, Electrical Engineering, Civil and Environmental Engineering, Biology, Statistics, Education and Information Sciences, Urban Planning, and Theater, Film, and Television.



CENS was established in 2002 as a National Science Foundation Science and Technology Center and is a partnership of UCLA, UC Riverside, UC Merced, USC, and Caltech.

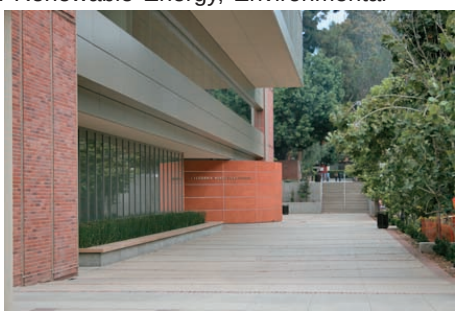
Electrical Engienering Professors Deborah Estrin, Jack W. Judy, William J. Kaiser, Gregory J. Pottie, Mani B. Srivastava, John D. Villasenor, and King Yao and their students are active members of the Center.

California NanoSystems Institute (CNSI)

The California NanoSystems Institute is a research center that is run jointly by UCLA and UC Santa Barbara. CNSI was established in 2000 with $100 million from the State of California and an additional $250 million in federal research grants and industry funding. Its mission is to encourage university collaboration with industry and enable the rapid commercialization of discoveries in nanosystems. In particular, CNSI is working to:

- establish a world-renowned center for nanosystems research and development
- develop commercial applications of CNSI's technology
- educate the next generation of scholars in nanosystems R&D
- promote regional development through commercial use of nanotechnology
- generate public appreciation and understanding of nanotechnology

The work conducted at the CNSI represents world-class expertise in five targeted areas of nanosystems-related research including: Renewable Energy, Environmental Nanotechnology and Nanotoxicology, NanoBiotechnology and Biomaterials, NanoMechanical and NanoFluidic systems, and NanoElectronics, Photonics and Architectonics. CNSI's new building on the campus of UCLA is home to eight core facilities which will serve both academic and industry collaborations.

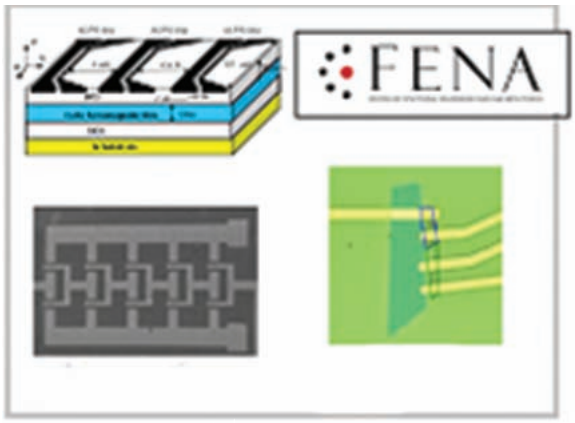


In 2007, the CNSI moved into a brand new 188,000 square foot, world-class research facility on the UCLA campus.

CNSI members who are on the faculty at UCLA and UCSB represent a multi-disciplinary team of some of the world's preeminent scientists in the fields of materials science, molecular electronics, quantum computing, optical networking and molecular medicine, to cite but a few examples. Professors Kang Wang, Jack Judy, Diana Huffaker, Aydogan Ozcan, Vwani Roychowdhury, Bahram Jalali, and Jason Woo of the Electrical Engineering Department are members of CNSI. Professor Kang Wang is the Associate Director.

Center on Functional Engineered Nano Architectonics (FENA)

FENA is part of the Focus Center Research Program (FCRP) initiated by the Semiconductor Research Corporation in an effort to expand pre-competitive, cooperative, long-range applied microelectronics research at US universities. The center, which was established in 2003, will receive $13.5 million over the first three years, and as much as $70 million over 10 years. FENA aims to create and investigate new nano-engineered functional materials and devices, and novel structural and computational architectures for new information processing systems beyond the limits of conventional CMOS technology.

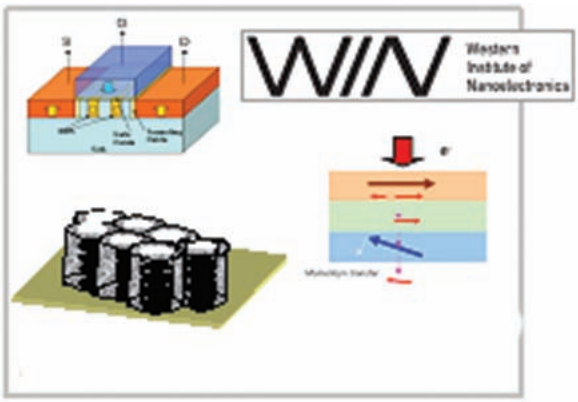


Some examples of FENA Center devices and circuit research and development projects.

FENA has 42 distinguished principal investigators from broad areas such as Materials Science, Chemistry, Electrical Engineering, Bio Engineering, Mathematics, Applied Physics, and Computer Engineering, from 17 of America's most elite research universities. The center is led by Professor Kang Wang of the Electrical Engineering Department. FENA embraces the current opportunity to create and explore the next generation of nanoscale semiconductor technology to the borders of ultimate CMOS and beyond: inventing the heterogeneous interfaces of new nanosystems, enabling a combination of biological and molecular functions, and revolutionizing the paradigms of information processing and sensing. These new nanostructured materials will provide the basis for the continued expansion of the semiconductor industry and the creation of new applications of monolithically integrated (CMOS, molecular and biomolecular) nanosystems. FENA plays a key role in America's technology competitiveness as it addresses industry and DoD needs using the research university system, i.e. long-range, innovative applied research.

Western Institute of Nanoelectronics (WIN)

The Western Institute of Nanoelectronics is a multidisciplinary center that is among the world's largest spintronics efforts. WIN was established in 2006 and is headquartered at UCLA, led by Electrical Engineering Professor Kang Wang. The institute involves collaborations among 8 national universities with 32 co-PIs. The institute's mission is to explore and develop advanced research devices, circuits and nanosystems with performance beyond conventional Complementary Metal Oxide Semiconductors (CMOS) devices. During the first phase (4 years), WIN's focus is on creating computation using nano-spintronics. Such a mission requires the research of new materials, devices, device-device interactions, circuits and architectures. The Western Institute of Nanoelectronics was established with funding totaling over $20M which includes industrial support and UC Discovery matching grant. WIN industry partners are organized through the Nanoelectronics Research Initiative which includes semiconductor companies such as Intel, IBM, Texas Instruments, AMD, Freescale and MICRON. In 2008, the National Institute of Standards and Technology (NIST), a federal technology agency, also joined the sponsoring industry consortia. The WIN center is a unique arrangement that engages private industry, the California Government, the federal government and top US universities targeting the development on new devices and circuits based on spintronics.



Some examples of WIN Center spintronic research and development projects.

Endowed Chairs

Professor Deborah Estrin of the UCLA Computer Science and Electrical Engineering Departments holds the Jonathan B. Postel Chair in Computer Networking in recognition of her ground-breaking research. This position was established by Dr. Postel's former colleagues to honor and recognize his extraordinary achievements in the networking field over the course of his 30-year career as a leading spokesman and architect of systematic organization in the rapidly growing online community. "Having worked with Jon Postel for many years as a researcher in his Computer Networks division, and as a member of the larger Internet research community, the Chair is particularly meaningful," says Prof. Estrin. She is also Director of the Center for Embedded Networked Sensing (CENS), an NSF Science and Technology Center. CENS is a major research enterprise developing wireless sensor systems and applying this revolutionary technology to radically transform critical scientific and societal applications. In 2003, Estrin was named one of Popular Science's Brilliant 10, an annual list of young scientists conducting ground-breaking work, for her research in embedded sensor networks and its applications in environmental monitoring.

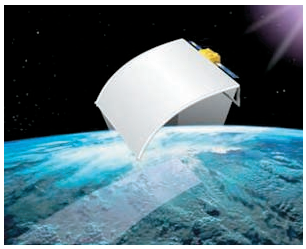
Professor Tatsuo Itoh, Northrop Grumman Chair in Microwave and Millimeter Wave Electronics, is a pioneer in electromagnetic engineering for microwave and wireless components, and heads the UCLA EE Department Microwave Electronics Laboratory. The laboratory has been engaged in a number of research projects, ranging from theoretical investigation to practical implementation of various microwave-related topics. The laboratory is working on enhancing the capability of retrodirective array for automatic target tracking and communication. Prof. Itoh's group has accomplished several unique capabilities previously unavailable, including a retrodirective array that can be reconfigured from the retrodirective mode to a direct conversion receiver/transmitter. The laboratory has also spearheaded the research and development of microwave applications of metamaterial structures. Unlike other research efforts in the world working on this subject, Prof. Itoh and his group have invented a uniquely different approach that provides low loss broadband capability. They have developed many microwave components with unusual or unique capabilities, including an electronically controlled antenna with 180 degree coverage and a variable radiation pattern, a very compact directional coupler, dual band circuits for high power high efficiency amplifiers, etc. A spin-off project is the development of small antennas for wireless communication (ten times smaller than conventional antennas).

8-Antenna Millimeter-Wave Radar Receiver with Performance of 12 Antennas

Professor Yahya Rahmat-Samii, Northrop Grumman Chair in Electromagnetics, is a well-known international authority in his field and heads the UCLA EE Department Antenna Research, Analysis and Measurement (ARAM) Laboratory. Dr. Rahmat-Samii has authored and co-authored over 720 technical journal articles and conference papers and has written 25 book chapters and three books. He has received numerous awards, including the 2007 Chen-To Tai Distinguished Educator Award of the IEEE Antennas and Propagation Society. He was elected to the National Academy of Engineering in 2008.

Prof. Rahmat-Samii's pioneering research activities cover many areas including: (a) Advanced Reflector Antenna Designs and Compensations (in which antenna concepts and designs are utilized in many planetary space missions, soil moisture remote sensing instruments, direct broadcast satellites, and outer space missions); (b) Personal Communication Antennas including Human Interactions (ARAM is considered one of the prominent research groups in the area of communication antennas for mobile units, MIMO, wearable and implanted applications. It

is among the pioneering groups to include the effects of the human biological tissues in simulation models); (c) Nature-Based Optimization Techniques in Electromagnetics (Prof. Rahmat-Samii pioneered activities in the application of the genetic algorithms and particle swarm optimizations in electromagnetics and antenna research. Many innovative and multifunction communication antennas, radar absorbing structures, and antenna array topologies have been designed using these techniques); (d) Antenna Measurements and Diagnostics Techniques (Advanced measurements and diagnostic techniques for antenna characterization have been developed). For the first time ever, the indoor bipolar near field measurement technique has been demonstrated. A microwave holography technique for antenna diagnostics including phaseless measurements has also been developed.



Remote Sensing Antenna

Professor Kang L. Wang, Raytheon Chair Professor of Physical Science, received his BS (1964) degree from National Cheng Kung University and his MS (1966) and PhD (1970) degrees from the Massachusetts Institute of Technology. He is recognized internationally as a leader in nanotechnology. He serves on the editorial board of the Encyclopedia of Nanoscience and Nanotechnology (American Scientific Publishers). He also currently serves as the Director of the MARCO Focus Center on Functional Engineered Nano Architectonics (FENA), an interdisciplinary Research Center funded by the Semiconductor Industry Association and Department of Defense to address the need of information processing technology beyond scaled CMOS; and was named the Director of Western Institute of Nanoelectronics (WIN) — a coordinated multi-project Research Institute. WIN is funded by NRI, Intel and the State of California Current ongoing projects are aimed at spintronics for low power applications. Prof. Wang was also the founding director of the Nanoelectronics Research Facility at UCLA (established in 1989) with an infrastructure to further research in nanotechnology. In addition to these technical leadership contributions, he has provided academic leadership in engineering education. He was the Dean of Engineering from 2000 to 2002 at the Hong Kong University of Science and Technology. Prof. Wang's research includes nanoelectronics, spintronics and new architectures for nanodevices.

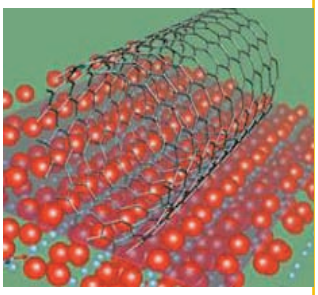


Figure representing nanowire synthesis

View of campus facing northeast

View of campus facing northwest

Members of the National Academies

Asad A. Abidi – National Academy of Engineering

Professor Asad A. Abidi has been with the Electrical Engineering Department since 1985. In 2007, he was inducted to the National Academy of Engineering for his contributions to the development of MOS integrated circuits for RF Communications. Prior to his tenure with the department, Abidi worked at Bell Laboratories, Murray Hill, NJ, as a member of the technical staff in the Advanced LSI Development Laboratory. He has received a number of awards and honors throughout his career, including the 1988 TRW (now Northrop Grumman) Award for Innovative Teaching, the 1997 IEEE Donald G. Fink Award, presented for the most outstanding survey, review, or tutorial paper published in the IEEE transactions, journals, magazines, or in the proceedings during a given year, and the 2008 IEEE Donald O. Pederson Award in solid state circuits.

M. C. Frank Chang – National Academy of Engineering

Professor Mau-Chung Frank Chang was elected to the National Academy of Engineering in 2008 for his contributions in development and commercialization of III-V-based heterojunction bipolar transistors (HBTs) and field-effective transistors (FETs) for RF wireless communications. Prior to joining UCLA, Professor Chang was the Assistant Director at Rockwell Science Center where he successfully developed and transferred AlGaAs/GaAs Heterojunction Bipolar Transistor (HBT) and BiFET (Planar HBT/MESFET) integrated circuits technologies from the research laboratory to the production line. His research has primarily focused on the development of high-speed semiconductor devices and integrated circuits for RF and mixed-signal communication and interconnect system applications. Professor Chang received the IEEE David Sarnoff Award (IEEE-wide Technical Field Award) in 2006 and the Pan Wen-Yuan Foundation Award in 2008.

Robert S. Elliott – National Academy of Engineering

Professor Emeritus Robert S. Elliott has had a long and illustrious career at UCLA. He served as the first Electrical Engineering Department Chair in the (then) School of Engineering and Applied Science and was the first person to hold the Hughes Distinguished Chair in Electromagnetics at UCLA. He became a Fellow of the IEEE in 1961, and was the recipient of the APS Distinguished Achievement Award in 1988. Also in 1988, and even more importantly, Dr. Elliott was honored by the National Academy of Engineering "for basic contributions to the electromagnetic theory and design of array antennas, and for outstanding leadership in engineering education". During his career at UCLA Prof. Elliott also was the recipient of several Best Teacher Awards, and two IEEE Best Paper Awards. In 2000 he received an IEEE Third Millennium Medal. Dr. Elliott is also the author of two seminal electrical engineering textbooks, *Antenna Theory and Design* and *Electromagnetics*.

Tatsuo Itoh – National Academy of Engineering

Professor Itoh has pioneered a research area in interdisciplinary electromagnetics beyond traditional electromagnetic engineering. Elected to the National Academy of Engineering in 2003, his citation reads, "For seminal contributions in advancing electromagnetic engineering for microwave and wireless components, circuits, and systems". In his early career, he developed a number of numerical methods for microwave problems. Based on one of these methods, he then developed the first CAD program package for design of E-plane filters for millimeter wave systems such as radio, radar, and remote sensors. More recently, his effort has been directed to coherently combining solid state devices and electromagnetic circuits for improved cost effectiveness and system performance. From this effort, the first global simulator for the RF frontend was developed, dealing with antennas, passive and active microwave circuits at the same time. He has also created the Active Integrated Antenna scheme in which the antenna is not only a radiating element but also serves as a circuit element for the RF front end, particularly at millimeter wave frequencies.

Stanley Osher – National Academy of Sciences

Professor Stanley Osher was elected to the National Academy of Sciences for "major contributions to algorithm development and applications in level set methods, high-resolution shock capturing methods, and PDE-based methods in imaging science." He has been at UCLA since 1976 and is Director of Special Projects at the Institute for Pure and Applied Mathematics. He is the co-inventor of level set methods for computing moving fronts, numerical methods for computing solutions to hyperbolic conservation laws and Hamilton-Jacobi equations, and total variation and other PDE-based image processing techniques. Dr. Osher was a Fulbright and Alfred P. Sloan Fellow, and has received the NASA Public Service Group Achievement Award, the Japan Society of Mechanical Engineers Computational Mechanics Award, the SIAM Pioneer Prize, and the SIAM Kleinman Prize.

C. Kumar Patel – National Academy of Sciences, National Academy of Engineering

Professor Patel holds a joint professorship with the Electrical Engineering and Physics Departments at UCLA. He has made numerous seminal contributions in several fields, including gas lasers, nonlinear optics, molecular spectroscopy, pollution detection and laser surgery. He has received numerous honors, including the National Medal of Science, for his invention of the carbon dioxide laser. He has also received the Lomb Medal of the Optical Society of America, the Franklin Institute's Ballantine Medal, the Pake Prize of the American Physical Society, and the Coblentz Society's Coblentz Prize.

Yahya Rahmat-Samii – National Academy of Engineering

Professor Yahya Rahmat-Samii was elected to the National Academy of Engineering in 2008 for his pioneering contributions to the design and measurement of reflector and hand-held device antennas. Many of his designs concepts are currently used in cell phones, planetary spacecraft, earth-observation satellites, and satellite dishes. Prior to joining UCLA Engineering, he was a Senior Research Scientist at NASA's Caltech Jet Propulsion Laboratory (JPL). He is a Distinguished Professor of Electrical Engineering and holds the Northrop Grumman Chair in Electromagnetics. His honors include the 2007 Chen-To Tai Distinguished Educator Award from the IEEE Antennas and Propagation Society; the 2005 International Union of Radio Science's Booker Gold Medal; the 2000 Antenna Measurement Techniques Association's Distinguished Achievement Award; the IEEE's Third Millennium Medal; a Distinguished Alumni Award from the University if Illinois ECE Department, Urbana-Champaign.

Henry Samueli – National Academy of Engineering

Dr. Henry Samueli was elected to the NAE in recognition of his "pioneering contributions to academic research and technology entrepreneurship in the broadband communications system-on-a-chip industry". Dr. Samueli has over 25 years of experience in the fields of digital signal processing (DSP) and communications systems engineering. He is widely recognized as one of the world's leading experts in the field of broadband communications circuits. He received his BS, MS and PhD degrees in electrical engineering from UCLA. Since 1985, Dr. Samueli has been a professor in the Electrical Engineering Department where he has supervised advanced research programs in DSP and broadband communications, and is also well known as the cofounder of Broadcom Corporation in 1991.

Jason Speyer – National Academy of Engineering

Professor Jason Speyer was elected to the National Academy of Engineering for "the development and application of advanced techniques for optimal navigation and control of a wide range of aerospace vehicles." He pioneered new optimal deterministic and stochastic control, team and differential game strategies, estimation, and model-based fault detection, identification, and reconstruction theories and algorithms, as well as matrix calculus of variations for the Apollo autonomous navigation system. He pioneered the development and mechanization of periodic optimal control with applications to aircraft fuel-optimal cruise and endurance. His efforts in differential carrier phase GPS blended with an inertial navigation system, was applied to formation flight for drag reduction, and achieved centimeter accuracy in flight tests. Dr. Speyer is a fellow of AIAA and IEEE (Life Fellow) and received the IEEE Third Millennium Medal as well as several AIAA Awards.

Adaptive Filters

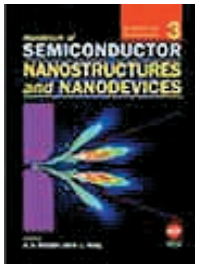
A. H. Sayed, *Wiley, NY, 2008*

Adaptive filtering is a topic of immense practical and theoretical value, having applications in areas ranging from digital and wireless communications to biomedical systems. Now, preserving the style and main features of the earlier award-winning publication, *Fundamentals of Adaptive Filtering* (2005 Terman Award), Professor Sayed offers readers and instructors a concentrated, systematic, and up-to-date treatment of the subject in this valuable new book. Adaptive Filters allows readers to gain a gradual and solid introduction to the subject, its applications to a variety of topical problems, existing limitations, and extensions of current theories. The book consists of eleven parts—each part containing a series of focused lectures and ending with bibliographic comments, problems, and computer projects with MATLAB® solutions available to all readers.

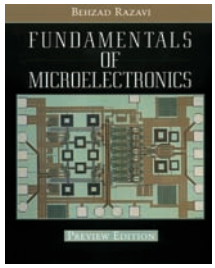
Fundamentals of Microelectronics

R. Razavi, *Wiley, NY, 2008*

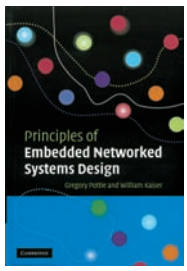
With the advances in the semiconductor and communication industries, it has become increasingly important for electrical engineers to develop a good understanding of microelectronics. This book addresses the need for a text that teaches microelectronics from a modern and intuitive perspective. Guided by the author's industrial, research, and academic experience, the topics, the order, and the depth and breadth are chosen so as to efficiently impart analysis and design principles that the students will find useful as they enter the industry or graduate school. A key feature of this book is its synthesis- or design-oriented approach, i.e., it states a design problem and attempts to arrive at a solution using basic principles, presenting both failures and successes in the process.



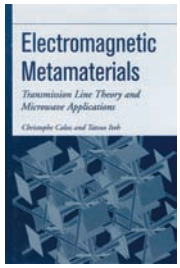
Semiconductor Nanostructures and Nanodevices
A. L. Balandin and K. L. Wang
American Scientific Publishers, 2006



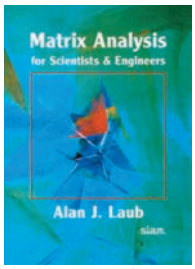
Fundamentals of Microelectronics
B. Razavi
John Wiley and Sons, 2006



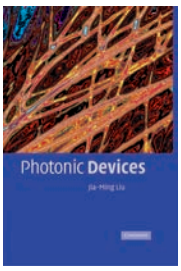
Principles of Embedded Networked Systems Design
G. Pottie and W. Kaiser
Cambridge University Press, 2005



Electromagnetic Materials
C. Caloz and T. Itoh
Wiley-IEEE Press, 2005

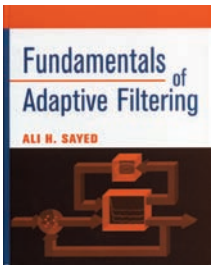


Matrix Analysis for Scientists and Engineers
A.J. Laub
SIAM Press, 2005

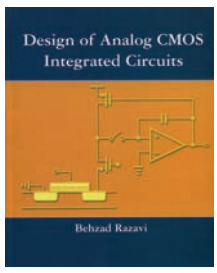


Photonic Devices
J-M. Liu
Cambridge University Press, 2005

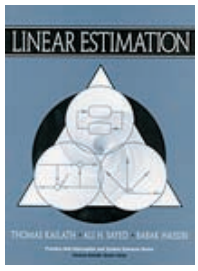
Convex Optimization
S. Boyd and L. Vandenberghe
Cambridge University Press, 2004



Fundamentals of Adaptive Filtering (2005 Terman Award)
A.H. Sayed
Wiley, 2005



Design of Analog CMOS Integrated Circuits
B. Razavi
McGraw Hill, 2000



Linear Estimation
T. Kailath, A.H.Sayed, B. Hassibi
Prentice-Hall, 1999

Seminar Series in Electrical Engineering

During the academic year 2007-2008, the department was pleased to host a number of outstanding speakers covering a broad range of topics.

Fall 2007 (Signals and Systems Area)

Professor Abeer Alwan, organizer

- **E. Candes** (Caltech): Compressive Sensing
- **J. Hansen** (UT Dallas): Speech & Speaker Recognition: Recent Advances for In-Vehicle Speech Systems
- **R. Lyon** (Google): Cochrea Modeling Retrospective
- **M. Effros** (Caltech): Network Source Coding: Pipe Dream or Promise
- **Z.-Q. (Tom) Luo** (U. of Minnesota): Performance Analysis of Quasi Maximum Likelihood Dectection Based on Semidefinite Relaxation
- **A. Lazar** (Columbia University): Time Encoding Machines.
- **E. Soljanin** (Bell Labs): What are the Benefits of Coding in Content Distribution Networks?
- **K. Ramchandran** (Berkeley): Smart Networks of Dense Nodes Using Distributed Signal Processing and Coding
- **S. Young** (Cambridge University, UK): Using POMDPs for Spoken Dialogue Management

Winter 2008 (Circuits and Embedded Systems Area)

Professor Puneet Gupta, organizer

- **F. Vahid** (UC Riverside): Self-Improvinig Computer Chips - Warp Processing
- **A. Neureuther** (UC Berkeley): Lithography Physics, Models and Technology Pathways to 7nm Half-Pitch
- **M. Breuer** (USC): One Person's Trash is Another Person's Treasure
- **A. Raghunathan** (NEC Labs): Embedding Security into Embedded Systems
- **M. Veloso** (Carnegie Mellow University): Multi-Robot Intelligence
- **R. Puri** (IBM Research): Design and CAD Challenges for 45nm CMOS and Beyond
- **D. Sylvester** (University of Michigan, Ann Arbor): Energy-Driven Circuit Design for Ubiquitous Sensing Applications

Spring 2008 (Physical and Wave Electronics Area)

Professor Benjamin Williams, organizer

- **G. M. Bebeiz** (UC San Deigo): High-Performance Microwave and Millimeter-Wave Phased Arrays Imaging Systems Using CMOS and SiGe RFICs
- **I. Appelbaum** (University of Delaware): Silicon Spintronics
- **E. P. Ippen** (MIT): Clocks, Combs and Optical Arbibrary Waveforms
- **S. S. Iyer** (IBM): Beyond Scaling - Teaching the Old Dog some New Tricks!
- **D. W. Prather** (University of Delaware): Millimeter Wave Photonics: From Materials, Devices, and Integration to Systems and Applications
- **C. Gmachi** (Princeton): Mid-Infrared Quantum Cascade Lasers
- **O. Painter** (Caltech): Nanophotonics Hardware for Quantum Information Science and Applications
- **U. Mishra** (UC Santa Barbara): Gallium Nitride Electronics: Providing Solutions Beyond Conventional Semiconductors

Annual Research Review

Professor Paulo Tabuada, Chair; Professors Rajeev Jain and Dejan Markovic, Co-chairs

Our annual research review was held during Winter 2008. Its purpose was to provide a forum in which graduate students could present their latest research results and answer questions from industrial and government sponsors, and where attending guests can gain an update on recent and ground-breaking research.

The event emphasized the following key areas:

- Emerging Internet Technology
- Emerging Wireless Technology
- Emerging Nanotechnology
- Emerging Tele-Health
- Emerging Web Applications
- Emerging Software-Defined Radio Technology
- Emerging Distributed Systems

Over 40 companies sent representatives to interact with our students and faculty:

Agilent Technologies, Aktino, Alpine Electronics, Ansoft Corporation, Baxter, Boeing, Broadcom, Cisco Research, Crocker Capital, ECA, Escape Communications, Foxconn Electronics, HRL Laboratories, Intel, Intel Capital, JPL, Linear Technology, Lockheed Martin, Lux Capital Management, Miramar Venture Partners, Moldex-Metric, Mojix, Northrop Grumman, Photonic Corporation, Proteus, Qualcomm, Rambus, Raytheon, Realtek Group, SANYO Technology Center, Skyworks, Sony, Sony Pictures Imageworks, Tenco, The Aerospace Corporation, ValuePoint Growth Partners, ViaSat, Warner Brothers, Westside Environmental Technology, WiLinx, Yahoo.

Every year the department sponsors focused workshops on topics of heightened interest with the participation of faculty, students, industry, and invited speakers.

Workshop on Integrated Circuits NeuroTechnology

Professors Jack Judy and Dejan Markovic, organizers — May 28, 2008

- **Itzhak Fried** (UCLA): Microelectrode Recordings from the Human Brain during Cognitive Tasks
- **Richard Staba** (UCLA): Chronic In-Vivo Macro- and Microelectrode Recordings in Humans
- **Pedro P. Irazoqui** (Purdue University): Clinical Prosthetic Devices for Glaucoma, Epilepsy, and Traumatic Brain Injury Repair
- **Arto V. Nurmikko** (Brown University): Implantable Microsystems for Brain Interfaces
- **Thomas Jochum** (Duke University): Possible Impediments to Clinical Approval of Cortical Neural Recorders
- **Reid R. Harrison** (University of Utah): Development and Testing of the Utah Integrated Neural Interface
- **Wentai Liu** (University of California, Santa Cruz): Miniatured Wireless Integrated Circuits for Neural Interface Applications
- **Philip Troyk** (Illinois Institute of Technology): ASIC Designs for Neural Implants - Challenges and Solutions
- **Raymond Campagnolo** (CEA LETI, France): Development of CMOS ASIC for Implantable Neurobiological Applications
- **Jack W. Judy** and **Dejan Markovic** (UCLA): System Architecture for Multichannel Wireless Neural Recording
- **John Haris** (University of Florida): Pulse-based Signal Compression for Neural Recording

Faculty Awards

Professors M. C. Frank Chang and Yahya Rahmat-Samii have been elected to the National Academy of Engineering, the highest professional lifetime distinction accorded to American engineers. Professor Chang was honored for the development and commercialization of GaAs power amplifiers and integrated circuits, and Professor Rahmat-Samii was honored for his contributions to the design and measurement of reflector and handheld-device antennas.

Professor Asad A. Abidi was elected to the National Academy of Engineering in 2007for his contributions to the development of integrated circuits for wireless communication circuits in metal–oxide–semiconductor (CMOS) technology used to fabricate microprocessors and digital signal processors. He was also awarded the 2008 IEEE Donald O. Pederson Award in Solid-State Circuits for his "pioneering and sustained contributions in the development of RF-CMOS."

Associate Professor Diana Huffaker has been selected to receive the prestigious National Security Science and Engineering Faculty Fellow (NSSEFF) Award from the Department of Defense. NSSEFF provides grants to top-tier researchers from U.S. universities to conduct long-term, unclassified, basic research of strategic importance to DoD. Up to $3 million of research support is granted to each NSSEFF Fellow for up to five years. Professor Huffaker received the award in recognition of her project entitled "*Exploring Dissimilar and Nanomaterials Integration as a Platform for New Medium and Long Wave Infrared Device Functionality*."

Professor Frank Chang has been awarded the 2008 Pan Wen-Yuan Award**.** The award is regarded as Taiwan's most prestigious technical award.

Four Electrical Engineering faculty members have been elevated to the grade of IEEE Fellow: Professor Abeer Alwan "for contributions to speech perception and production modeling and their applications," Professor Diana Huffaker "for development of optoelectronic materials and processing," Professor Jia-Ming Liu "for contributions to the control and applications of nonlinear dynamics of lasers," and Professor Mani Srivastava "for contributions to energy-aware wireless communications and sensor networking."

Faculty Recognitions

- Assistant Professor Chris Nieman received the Plasma Physics Junior Faculty Award from the Department of Energy to fund his research on ultra-bright laser based x-ray sources.
- Assistant Professor P. Gupta received the 2007 European Design Automation Association (EDAA) Outstanding Dissertation Award in the topic "*New directions in physical design, design for manufacturing and CAD for analog circuits*".
- The Lockheed Martin Excellence in Teaching Award recognized Professor Asad Abidi for outstanding teaching in the UCLA Henry Samueli School of Engineering and Applied Science.
- Professor Mihaela van der Schaar received the 2008 IBM Faculty Award in recognition of the quality of her research program on new video streaming techniques and fairness policies for real-time multimedia transmission over enterprise networks to industry.

Royce Hall

Royce Hall Entrance

Royce Hall Auditorium

Student Awards

- EE and CS graduate students Y. Hu (Professor L. He, advisor) and V. Shih (Professor R. Majumdar, advisor) win the third IEEE Programming Challenge at the IEEE International Workshop on Logic and Synthesis, held June 4-6, 2008, in Lake Tahoe.

- The paper entitled ``Finite Element Analysis of Dielectric Metamaterial Structures Excited by an NRD Guide'' by N. Michishita, T. Ueda and Professor T. Itoh receives the 2008 Research Award at the 26th Conference of Japan Society for Simulation Technology.

Ph.D. Siblings Franklin and Margaret Chiang

- Professors William Kaiser and Majid Sarrafzadeh, along with collaborators from the UCLA Medical School and the Veteran's Administration, have been awarded the Best Paper Award at BodyNets 2008 for their paper entitled: "*The SmartCane System: An Assistive Device for Geriatrics*." BodyNets is an annual conference focused on the topic of sensor networks applied to biomedical monitoring.The Smart Cane system developed by Professors William Kaiser and Majid Sarrafzadeh has also been selected to be presented as a demonstration at the Microsoft TechFest 2008, which is hosted by Microsoft Research. Very few teams outside of Microsoft are invited to this event.

- The paper "XCXO: An Ultra-low Cost Ultra-high Accuracy Clock System for Wireless Sensor Networks in Harsh Remote Outdoor Environments" by T. Schmid, J. Friedman, Z. Charbiwala, Y. Cho, and Professor M. Srivastava is selected as a winner for the 2008 Student Design Contest held by the DAC/ISSCC and Design Automation Conferences.

- Ph.D. student Harish Rajagopalan (Professor Y. Rahmat-Samii, advisor) is awarded first place in the 2008 Student Paper Competition by The United States National Committee for the International Union of Radio Science (URSI). The award is for his paper entitled "RF MEMS Actuated Reconfigurable Reflectarray: A Novel Patch-Slot Element Design."

- Ph.D. student Qiyue Zou (Professor A. H. Sayed, advisor) receives the 2007 IEEE Signal Processing Young Author Best Paper Award based on his paper on "The Cramer-Rao Lower Bound for Bilinear Systems, published in the IEEE Transactions on Signal Processing, vol. 54, no. 5, pp. 1666-1680, May 2006, and co-authored with L. Zhiping and R. Ober.

- Graduate student Jintae Kim (Professor Ken Yang, advisor) received the SSCS pre-doctoral fellowship. This is a prestigious award to students in the integrated circuits community world-wide.


2007-2008 Outstanding Student Award Recipients. Left to right: Prof. Srisvastava, Varun Raghunathan, Prof. Jalali, Prof. Markovic, Rashmi Nanda, Frank Kuo, Prof. Sayed

2008 Outstanding Student Awards

- Christina Huang Memorial Prize: Mohammad Ardakani
- Outstanding Bachelor of Science Award: Frank Kuo
- Outstanding MS Awards: Rashmi Nanda
- Outstanding PhD Award: Varun Raghunathanl

Rob N. Candler
(Physical and Wave Electronics)
Assistant Professor
Ph.D. Stanford University, 2006

Physical sensors at the micro/nano-scale, Interface of Microelectromechanical Systems (MEMS) and biology, RF MEMS; New technologies for packaging and devices; Energy dissipation mechanisms and fundamental limitations of micro/nanoscale resonators and sensors.

Jin Hyung Lee
(Signals and Systems)
Assistant Professor
Ph.D., Stanford University, 2004

Neural information processing and plasticity; advanced imaging techniques for biomedical applications, neurosciences and neural-engineering; magnetic Resonance Imaging (MRI); development of novel image contrast strategies; Alternative image acquisition, reconstruction, and processing techniques;

2008 HSSEAS Commencement

Adjunct Professors

N.G. Alexopoulos
E. Biglieri
C. Chien
D. Cheung
M. Eshaghian-Wilner
M.P. Fitz
G. Franceschetti
B. Houshmand
F. Paganini
J.N. Schulman
I. Verbauwhede
M.C. Wu
E. Yablonovitch

Emeriti Professors

F.G. Allen
F.F. Chen
R.S. Elliott
S. E. Jacobsen
N. Levan
F.W. Schott
C. Viswanathan
P. K. C. Wang
J. Willis

FACULTY: Circuits and Embedded Systems Area

Asad A. Abidi
Ph.D., UC Berkeley, 1981

CMOS RF design, high speed analog integrated circuit design, data conversion, and other techniques of analog signal processing.

- Fellow, IEEE, 1996
- National Academy of Engineering, 2007

Danijela Cabric
Ph.D., UC Berkeley, 2007

Wireless communications system design; Cognitive radio networks; VLSI architectures of signal processing and digital communication algorithms; Performance analysis and experiments on embedded system platforms.

Mau-Chung Frank Chang
Ph.D., National Chiao-Tung University, 1979

CMOS RF design, high speed analog integrated circuit design, data conversion, and other techniques of analog signal processing.

- Fellow, IEEE, 1996
- National Academy of Engineering, 2008

Babak Daneshrad
Ph.D., UC Los Angeles, 1993

Digital VLSI circuits: wireless communication systems, high-performance communications integrated circuits for wireless applications.

Deborah C. Estrin
Ph.D., MIT, 1985

Wireless sensor networks, environmental monitoring, participatory mobile sensing.

- Fellow, IEEE, 2004
- Fellow, AAAS, 2001
- Fellow, ACM, 2000

Puneet Gupta
Ph.D., UC San Diego, 2007

Manufacturing, device, circuit and CAD techniques to enable design aware manufacturing and manufacturing aware design. Test structure design for generating abstracted process and variation models. Techniques for leakage power modeling and reduction.

Lei He
Ph.D., UC Los Angeles, 1999

Computer-aided design of VLSI circuits and systems, interconnect modeling and design, power-efficient computer architectures and systems, and numerical and combinatorial optimization.

William J. Kaiser
Ph.D., Wayne State University, 1984

Development of distributed networked, embedded computing for linking the Internet to the physical world: applications include distributed systems for factory automation, biomedical research, health care, space science, security, and defense.

- Fellow, American Vacuum Society (American Institute of Physics), 1990

Dejan Markovic
Ph.D., UC Berkeley, 2006

Power/area-efficient digital integrated circuits, VLSI architectures for wireless communications, optimization methods and supporting CAD flows.

Sudhakar Pamarti
Ph.D., UC San Diego, 2003

Mixed-signal IC design, signal processing and communication theory, especially the design of highly integrated wireless and wireline communication systems with particular emphasis on lowering cost and power consumption; design, silicon IC implementation, and verification of mixed-signal blocks.

Faculty: Circuits and Embedded Systems Area

Behzad Razavi
Ph.D., Stanford University, 1992

Analog, RF, and 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.

- Fellow, IEEE, 2003

Vwani P. Roychowdhury
Ph.D., Stanford University, 1989

Models of computation: parallel systems, quantum information processing, nanoscale and molecular electronics, statistical algorithms for large-scale information processing, combinatorics and complexity and information theory, bioinformatics, cryptography.

Henry Samueli
Ph.D., UC Los Angeles, 1980

Digital signal processing, communications systems engineering, and CMOS integrated circuit design for applications in high-speed data transmission systems.

- Fellow, IEEE, 2000
- Fellow, American Academy of Arts and Sciences, 2004
- National Academy of Engineering, 2003

Majid Sarrafzadeh
Ph.D., UI Urbana-Champaign, 1987

Embedded and reconfigurable computing; VLSI CAD; design and analysis of algorithms.

Mani B. Srivastava
Ph.D., UC Berkeley, 1992

Mobile and multimedia networked computing systems, design and synthesis of DSP systems, and low-power systems.

- Vice-Chair of Graduate Affairs
- Fellow, IEEE, 2008

Alan N. Willson, Jr.
Ph.D., Syracuse University, 1967

Theory and application of digital signal processing including VLSI implementations, digital filter design, nonlinear circuit theory.

- Fellow, IEEE, 1978

Chi-Kong Ken Yang, *Area Director*
Ph.D., Stanford University, 1998

High-speed data and clock recovery circuits for large digital systems, low-power, high-performance functional blocks and clock distribution for high-speed digital processing, and low-power high-precision capacitive sensing interface for MEMS.

FACULTY: Physical and Wave Electronics Area

Robert Candler
Ph.D., Stanford University, 2006

Physical sensors at the micro/nanoscale, Interface of Microelectromechanical Systems (MEMS) and biology, RF MEMS; New technologies for packaging and devices; Energy dissipation mechanisms and fundamental limitations of micro/nanoscale resonators and sensors.

Chi-On Chui
Ph.D., Stanford University, 2004

Heterostructure semiconductor devices and technology involving the application of novel device concepts and fabrication techniques to explore the quantum and strain effects at the nanoscale.

Harold R. Fetterman
Ph.D., Cornell University, 1968

Optical millimeter wave interactions, femtosecond evaluation of high-frequency devices and circuits, solid state millimeter wave structures and systems, biomedical applications of lasers.

- Fellow, IEEE, 1990
- Fellow, Optical Society of America, 1980

Warren S. Grundfest
M.D., Columbia University, 1980

Lasers for minimally invasive surgery, magnetic resonance-guided interventional procedures, laser lithotripsy, microendoscopy, spectroscopy, photodynamic therapy, optical technology, biologic feedback control mechanisms.

- Fellow, SPIE, 1996
- Fellow, American Institute of Medical & Biologic Engineers, 1996

Diana Huffaker
Ph.D., UT, Austin, 1994

Directed and self-assembled nanostructure solid-state epitaxy, optoelectronic devices including solar cells and III-V/Si photonics.

- Fellow, IEEE, 2008

Tatsuo Itoh
Ph.D., UI Urbana-Champaign, 1969

Microwave and millimeter wave electronics, guided wave structures, low power wireless electronics, integrated passive components and antennas.

- Fellow, IEEE, 1982
- National Academy of Engineering, 2003

Bahram Jalali
Ph.D., Columbia University, 1989

RF photonics, fiber optic integrated circuits, and Datacom systems.

- Fellow, IEEE, 2003
- Fellow, Optical Society of America, 2004

Chandrashekar Joshi
Ph.D., Hull University, England, 1979

Laser fusion, laser acceleration of particles, nonlinear optics, high-power lasers, plasma physics.

- Fellow, IEEE, 1993
- Fellow, Institute of Physics (U.K.), 1998
- Fellow, American Physical Society, 1990

Jack W. Judy
Ph.D., UC Berkeley, 1996

MEMS, microsensors, micro-actuators, microsystems and micromachining; magnetism and magnetic materials; neuro-engineering and neuro-silicon interfaces; distributed sensors, actuators, and information.

Jia-Ming Liu
Ph.D., Harvard University, 1982

Ultrafast optics and electronics, opto-electronics and semiconductor lasers, nonlinear optics, and optical-wave propagation.

- Fellow, American Physical Society, 2003
- Fellow, Optical Society of America, 1990
- Fellow, IEEE, 2008

Warren B. Mori
Ph.D., UC Los Angeles, 1987

Laser plasma interactions, advanced accelerator concepts, advanced light sources.

- Fellow, American Physical Society, 1995
- Fellow, IEEE, 2007

Christoph Niemann
Ph.D., University of Technology, Darmsstadt, 2002

Laser-plasma interactions, high-energy density physics, and inertial confinement fusion.

Aydogan Ozcan
Ph.D., Stanford University, 2005

Photonics and its applications to nano- and bio-technology.

Dee-Son Pan
Ph.D., California Institute of Technology, 1977

New semiconductor devices for millimeter- and submillimeter-wave generation and amplification, transport in small geometry semiconductor devices, generic device modeling.

C. Kumar Patel
Ph.D., Stanford University, 1961

Condensed matter physics, especially the structure and dynamics of “interesting systems”, broadly defined; spectroscopic techniques and detection methods; development of new laser systems.

- National Medal of Science, 1996
- National Academy of Engineering, 1978
- Fellow, IEEE, 1975
- National Academy of Sciences, 1974

Yahya Rahmat-Samii
Ph.D., UI Urbana-Champaign, 1975

Satellite, personal communications, microstrip, fractal, remote sensing, and radio astronomy antennas; electromagnetic bandgap structures; computational and optimization techniques, measurement and diagnostic techniques.

- Fellow, IEEE, 1985
- National Academy of Engineering, 2008

Oscar M. Stafsudd
Ph.D., UC Los Angeles, 1967

Quantum electronics, especially IR lasers and nonlinear optics; solid-state IR detectors.

Kang L. Wang
Ph.D., MIT, 1970

Nanoelectronics and optoelectronics, MBE and superlattices, microwave and millimeter electronics/optoelectronics, quantum computing.

- Fellow, IEEE, 1992

Yuanxun (Ethan) Wang
Ph.D., UT Austin, 1999

High performance antenna array and microwave amplifier systems for wireless communication and radar; numerical modeling techniques; fusion of signal processing and circuit techniques in microwave system design.

Benjamin Williams
Ph.D., MIT, 2003

Quantum cascade lasers in the terahertz frequency range, and the development of terahertz components based on sub-wavelength dimension for use in beam control, sensing, and imaging. Development of inter-subband and inter-sublevel based devices in low-dimensional nanostructures for electronic and optoelectronic applications.

FACULTY: Physical and Wave Electronics Area

Jason C.S. Woo, *Area Director*
Ph.D., Stanford University, 1987

Solid state technology, CMOS and bipolar device/circuit optimization, novel device design, modeling of integrated circuits, VLSI fabrication.

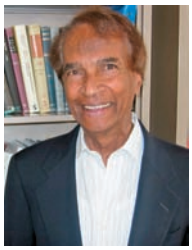
- Fellow, IEEE, 2005

Electrical Engineering Faculty at the 2008 Commencement ceremonies. Left to right (top to bottom): Professors K. Wang, J-M Liu, G. Pottie, W. Kaiser, Y. Rahmat-Samii, R. Wesel and M.B. Srivastava.

Abeer A. Alwan, *Area Director*
Ph.D., MIT, 1992

Speech processing, acoustic properties of speech sounds with applications to speech synthesis, recognition by machine and coding, hearing aid design, digital signal processing.

- Fellow, Acoustical Society of America, 2003
- Fellow, IEEE, 2008



A.V. Balakrishnan
Ph.D., University of Southern California, 1954

Laser beam distortion in atmospheric turbulence, control design for smart structures, and flight systems applications of adaptive control, nonlinear aeroelasticity, and wind power.

- Fellow, IEEE, 1996

Paganiotis D. Christofides
Ph.D., University of Minnesota, 1996

Control and system theory, with applications to chemical process control, advanced materials processing and water systems.

Rajeev Jain
Ph.D., Katholieke Universiteit, Leuven, Belgium, 1985

Embedded hardware/software design for signal processing systems-on-a-chip; CAD tools for design of high-performance signal processing architectures and development of ASICs for spread-spectrum modems and image compression.

- Fellow, IEEE, 1999

Alan J. Laub
Ph.D., University of Minnesota, 1974

Numerical linear algebra, numerical analysis, high-end scientific computation, and computer-aided control system design, especially algorithms for control and filtering.

- Fellow, IEEE, 1986

Jin Hyung Lee
Ph.D., Stanford University, 2004

Neural information processing and plasticity; advanced imaging techniques for biomedical applications, neurosciences and neural-engineering; magnetic Resonance Imaging (MRI); development of novel image contrast strategies; Alternative image acquisition, reconstruction, and processing techniques.

Stanley J. Osher
Ph.D., Courant Institute, New York University, 1966

Innovative numerical methods for applications ranging from image science to control to electromagnetics to computational physics and beyond.

- National Academy of Sciences, 2005

Gregory J. Pottie
Ph.D., McMaster University, 1988

Communication systems and theory, with applications to personal communications, channel coding, and wireless sensor networks.

- Fellow, IEEE, 2005

Izhak Rubin
Ph.D., Princeton University, 1970

Telecommunications and computer communications systems/networks; mobile wireless, optical, multimedia IP, ATM, satellite, and CATV networks; queueing systems, C3 systems/networks, network simulations and analysis, traffic modeling/engineering.

- Fellow, IEEE, 1987

Vwani P. Roychowdhury
Ph.D., Stanford University, 1989

Models of computation: parallel systems, quantum information processing, nanoscale and molecular electronics, statistical algorithms for large-scale information processing, combinatorics and complexity and information theory, bioinformatics, cryptography.

FACULTY: Signals and Systems Area

Ali H. Sayed
Ph.D., Stanford University, 1992

Adaptive and statistical signal processing, distributed processing, adaptive networks filtering and estimation, signal processing for communications, wireless networks, algorithms for large-scale structured computations.

- Fellow, IEEE, 2001
- Department Chairman

Stefano Soatto
Ph.D., Caltech, 1996

Computer vision, nonlinear estimation, control theory.

Jason Speyer
Ph.D., Harvard University, 1968

Stochastic and deterministic optimal control and estimation with application to aerospace systems; guidance, flight control, and flight mechanics.

- National Academy of Engineering, 2005
- Life Fellow, IEEE
- Fellow, AIAA, 1985

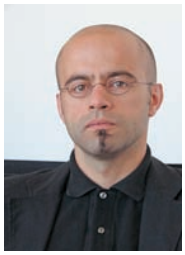
Mani B. Srivastava
Ph.D., UC Berkeley, 1992

Mobile and multimedia networked computing systems, design and synthesis of DSP systems, and low-power systems.

- Vice-Chair of Graduate Affairs
- Fellow, IEEE, 2008

Mihaela van der Schaar
Ph.D., University of Technology, Eindhoven, 2001

Theory and design of novel algorithms, standards and systems for multimedia coding, processing and ubiquitous communication over Internet and wireless networks.



Paulo Tabuada
Ph.D., Technical University of Lisbon, Portugal, 2002

Design of networked embedded control systems. Modeling, analysis and design of discrete-event, timed and hybrid systems. Hierarchical and distributed control design, geometric and algebraic control theory for nonlinear and Hamiltonian control systems, categorical systems theory.

Lieven Vandenberghe
Ph.D., Katholieke Universiteit, Leuven, Belgium, 1992

Optimization in engineering, applications in systems and control, circuit design, and signal processing.

- Vice-Chair of Undergraduate Affairs

John D. Villasenor
Ph.D., Stanford University, 1989

Communications, signal and image processing, joint source and channel coding, lattice vector quantization, wavelet filter design, wireless multimedia communications, and low complexity image and video coding architectures and algorithms.

Alan N. Willson, Jr.
Ph.D., Syracuse University, 1967

Theory & application of digital signal processing including VLSI implementations, digital filters, nonlinear circuit theory.

- Fellow, IEEE, 1978

Richard D. Wesel
Ph.D., Stanford University, 1996

Communication theory with interest in coded modulation including trellis codes and turbo codes for applications including mobile wireless communication systems, multiple antenna systems, and satellite communication systems.

Kung Yao
Ph.D. Princeton University, 1965

Communication theory, signal, acoustic, and array processing, wireless communication systems, sensor networks, chaos system theory, and VLSI and systolic algorithms and architectures

- Fellow, IEEE, 1994

Industrial Affiliates Program


Professor R. Jain

The Electrical Engineering Department is dedicated to initiating and forging partnerships with industry, in which both the school and the companies involved benefit from the exchange of technology innovations and talent. The Industrial Affiliates Program (IAP), initiated in 1981, is presently chaired by Professor Rajeev Jain, Vice-Chair of Industry Relations. IAP provides a variety of services that include:

- Nurturing the talent pipeline between UCLA and IAP members
- Providing access to UCLA intellectual capital
- Exploring collaborative research opportunities
- Providing access to state-of-the-art research facilities
- Enhancing industry visibility on campus

The department also serves as an invaluable consulting resource for affiliate members. In turn, a company's participation in IAP provides essential program enhancement and aid to students with a portion of the funds used for laboratory, instructional and other equipment needs.

There are two levels of membership in the program: as an associate member or as a full member. More details are available at the IAP website: http://www.ee.ucla.edu/Industry-home.htm

Administration

Ali H. Sayed, *Department Chairman*
Rajeev Jain, *Vice-Chair, Industry Relations*
Mani B. Srivastava, *Vice-Chair, Graduate Affairs*
Lieven Vandenberghe, *Vice-Chair, Undergraduate Affairs*

Department Committees

Chandrashekar Joshi, *Director, Center for High-Frequency Electronics*
Jack W. Judy, *Director, Nano-Electronics Research Facility*
Kung Yao, *Chair, Tenure Committee*
Behzad Razavi, *Chair, Recruitment Committee*
Chi-Kong Ken Yang, *Chair, Non-Tenure Committee*
Jia-Ming Liu, *Chair, Courses and Curriculum Committee*

ABET Committee

Abeer A. Alwan, *Professor and Area Director*
Rajeev Jain, *Professor and Vice-Chair*
Ali H. Sayed, *Professor and Department Chair*
Lieven Vandenberghe, Professor and *Vice-Chair*
Jason C.S. Woo, *Professor and Area Director*
Chi-Kong Ken Yang, *Professor and Area Director*

UCLA Electrical Engineering

Henry Samueli School of Engineering and Applied Science
Electrical Engineering Department
University of California
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