Department of Electrical & Computer Engineering

April 2007

Industrial Affiliates Newsletter

Department of Electrical and Computer Engineering: Quick Overview

The Department of Electrical and Computer Engineering at UC Davis has a long-standing tradition of continuing enhancement to undergraduate and graduate education and high quality research from its faculty. We are one of the largest departments in the College with 30+ ladder-rank faculty, 15 emeritus professors, and several adjunct and research faculty, post-docs and visiting scholars.

We serve over 700 undergraduate and 185 graduate students, meeting the needs of a diverse constituency. Our mission, research and educational objectives, and program objectives stem directly from the land grant origins of the University of California and our constituent's needs.

Our research activities are broadly divided into seven major areas of electrical and computer engineering. Specifically, our faculty actively conduct research in Communication, Signal & Image Processing; Computer Engineering; Electronic Circuits; Optoelectronics; RF, Micro- & Millimeter Waves; Solid State Electronic Devices and Systems & Control.

Our faculty's research and teaching activities receive constant recognition from professional communities and sponsoring agencies.

The level of extramural funding for research activities of the faculty is continuing to grow and it is over $5 million in the last year.

The department faculty have been very active in defining and developing new interdisciplinary research and collaborative efforts. The department has also been effective in

recruiting and training top graduate students in its multidisciplinary environment.

In addition to graduate student education and research, our undergraduate programs provide a rigorous foundation, and enhance the undergraduate experience through exposure to a strong research environment.

ECE Graduate Student Association: An Update

The ECE GSA is actively involved in many social, academic, and philanthropic activities. This year they have put on a canned food drive during the holiday season, started journal clubs for students and faculty, assisted first year students with preparing for preliminary exams, participated in the annual Picnic Day College of Engineering Float, helped recruit students from all across the country during our annual recruitment weekend, created a department t-shirt as a fundraiser, sponsored a pumpkin carving contest, and had some fun along the way. Led by ECE GSA President Nick Fontaine, and other GSA officers, Alex McCourt, Katie Metheany, Mat Temmerman, David Geisler, Zuowei Shen, Xi Wang, John Yan, and Robin Lin.

In this issue:

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Nick Fontaine

ECE GSA President

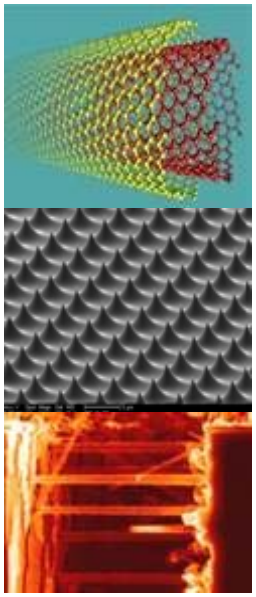
Communication, Signal and Image Processing

With 30+ ladder rank, 15 emeriti, and several adjunct and research faculty members, the ECE dept is home to numerous exciting research projects.

The Communication, Signal and Image Processing group focuses on research projects ranging from mathematical foundations to applications of signal processing in wireless communication, image processing, coding, storage systems, genomics, networking and several other application domains.

Present research projects focus on novel wireless digital communication system design and implementations, MIMO wireless transceiver optimization and crosslayer integration, space-time coded modulation and channel estimation, wireless LAN and WiMAX, new methods for hybrid ARQ equalization and decoding, higher order statistical signal processing, channel estimation and channel equalization, ultra-wideband (UWB) local area networks, cyclo-stationary signal processing, adaptive and array signal processing, image processing and coding based on image analysis and on properties of human perception, 3D sound perception modeling and simulation, customized 3D spatial hearing modeling and approximation for high-quality spatial sound simulation, event detection in seismic signals and target cueing in hyperspectral images.

Computer Engineering



The Computer Engineering group encompasses the research efforts of ten faculty members and their students. Research projects span over a wide range of topics ranging from high-level design specification and compilation to digital circuit design and optimization.

Currently, the following research topics are actively pursued in the computer engineering group: architecture, implementation and compilation for chip multiprocessors, embedded system for multi-media applications, distributed and collaborative embedded systems, energy-aware compilation, computer-aided design, verification and testing of digital systems, fault-tolerant computing and reliable data compression, life-time validation of digital systems, optimal instruction scheduling and register allocation in compilers, robust, stable and efficient management of network control plane, network measurement and monitoring, graphics and graphics architecture, and sensor networks.

Solid State Electronic Devices and Sensors

Department research activities are broadly divided into seven major areas of electrical and computer engineering.

The Solid-State group focuses on research projects involving fabrication of electronic materials and devices as well as non-electronic micro and nanostructures.

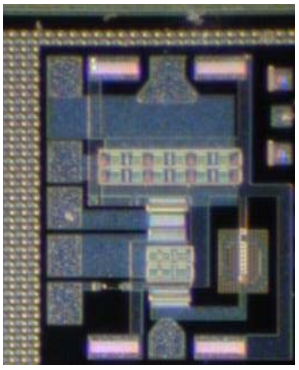
Research projects include investigation of kinetic phenomena during epitaxial growth of Si-Ge-C films; synthesis and device integration of semiconductor nano-structures; development of novel characterization techniques for quantum structures; nano-structured sensors; semiconductor wafer bonding and low-temperature wafer bonding of silicon and compound semiconductors; etch-stop development; field-emission vacuum microelectronics for flat-panel display and microwave amplifier application; micro-sensor packaging; microjoints for 3-D assembly; high-temperature electronic materials research; semiconductor opto-electronics and optical excitation of field emitter arrays; microfabricated bio and chemical analysis instruments; Silicon-on-Insulator (SOI) device physics and processing.

Electronic Circuits

This group's interests are in analog and digital circuit design, specifically focusing on designs for integrated circuits in CMOS technologies. The goal of the research is to develop new circuit architectures and techniques that advance the state of the art in specific areas, including the following: analog or mixed analog/digital implementations of advanced signal processing algorithms for digital magnetic recording, digital communications, including adaptive equalizers, Viterbi detectors, timing recovery circuits; analog-to-digital converters and their calibration; mismatch insensitive double-sampled delta-sigma modulators; low voltage circuits for data communications and conversion; circuitry for integrated sensors; development of CAD software for IC design; and design of multi-valued logic.

RF, Micro and Millimeter Waves

The research of this group focuses on the efficient generation and transfer detection of electromagnetic energy in the frequency ranges from approximately 100 MHz to greater than 100 GHz. Primary topics of research include active devices including the development of low power consumption, compact size and low-noise Bipolar and FET amplifiers and voltage controlled oscillators, operating in the lower microwave band of 0.9 - 2 GHz. Passive devices including the design of reduced-size microstrip coupling devices, filters, T-junction power divider circuits, and broadband direction-finding antennas; nonlinear microwave device research with extensive activity being directed toward active RF/microwave multipliers (1-30 GHz range), quasi-optical grid arrays and solid state devices to serve as high power millimeter wave oscillators, amplifiers, frequency multipliers, beam controllers and mixers; generation of picosecond signals using monolithically-fabricated nonlinear transmission lines; research centering on the automatic phase noise measurement system, which permits the analysis and modeling of the phase noise characteristics of oscillators, phase-locked loops and amplifiers used in wireless communication systems; photonic control of phase array antennas; and high-frequency characterization methods for low-dielectric constant thin films and biosensors.



Optoeletronics

The optoelectronics group performs research on devices and systems for optical communication and instrumentation. The objective is to develop new materials, devices, and system-concepts that will advance optical technology.

At present, the group is involved in the following research projects: design and modeling of transparent optical networks; research on space-switching and wavelength conversion techniques for Next Generation Network applications; design and fabrication of micromachined optical systems for fiber-optic networks; development and integration of organic polymeric films with large electro-optic effects into devices used for high-bandwidth modulation, second-harmonic generation, photonic integrated circuits, and phased-array antennas; investigation of optical gating of field emission from microtip arrays for advanced microwave tube applications; and development of new concepts for femto-second characteristics and application of femto-second lasers to the study of nonlinear optical devices.

The opto-electronic research facility consists of six laboratories equipped with state-of-the-art lasers and high-speed instrumentation for optical and electronic characterization. Fabrication of photonic integrated circuits and micromachined optical systems takes place in the ECE Microfabrication Facility. The opto-electronic group collaborates with researchers at several academic and industrial institutions, including UC Berkeley, Stanford University, Lawrence Livermore Lab and IBM Almaden.

Currently, the dept serves about 700 undergraduate and 185 graduate students. About two thirds of graduate students pursue the Ph.D. degree.

Systems and Control

This group focuses its research on control of constrained linear and nonlinear systems. The major research activities include nonlinear system theory, robust and reliable systems, adaptive control, intelligent control, neural systems, optimization-based design and control and rapid thermal process control.

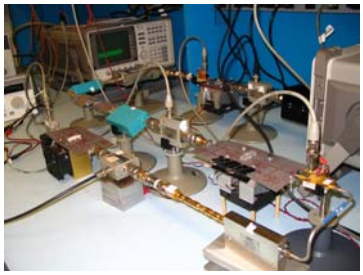
In the systems and control area research is performed on theoretical and/or design-oriented topics in the following areas: nonlinear systems and control theory, multi-input multi-output feedback systems, decentralized control, robust control, reliable control, adaptive control, and optimization-based design of nonlinear control systems;

Current activities in the decision and control area include decision support and scheduling for IC manufacturing, VLSI physical design automation, global and local optimization with applications, neural networks, and control system design.

Selected Research Activities:

Microwave Devices and Systems Laboratory

Prof. Rick Branner



The Microwave Devices and Systems Laboratory has been under the leadership of Professor G. Rick Branner for over 25 years. The research laboratory consists of four PhD researchers with well over 80 years of combined experience in Microwave and RF engineering. The nationally renowned curriculum has produced many hundreds of RF and Microwave Engineers over the course of its existence.

Our group is conducting research in several areas. A major area is the modeling of GaAs and wide band gap semiconductors including SiC and GaN. Devices include HEMT, PHEMT and MESFETS. Ground breaking work has been done on Large Signal Nonlinear Models for these devices.

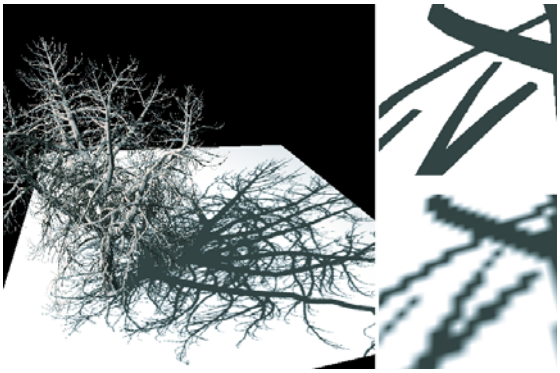
Other areas include phase noise characterization of semiconductor devices, and active and passive component development for microwave systems. Some examples of our work include active frequency multipliers, power amplifiers using SiC, diplexers, phased array and microstrip antennas.

Another area of investigation is focused on Radar detection of a selected class of objects in a dense clutter environment employing FM/CW and Ultra wideband technology.

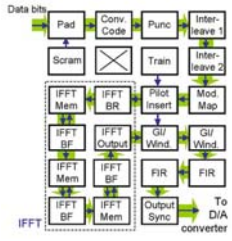
Under the leadership of Prof. G. Rick Branner, the Microwave Devices and Systems Laboratory focuses on projects in modeling of GaAs and wide band gap semiconductors including SiC and GaN.

Research in Graphics Hardware

Prof. John Owens



Assistant professor John Owens and his research group are investigating the use of graphics processors (GPUs) for general-purpose computation. The recent increases in the performance and programmability of the GPU have made it an attractive platform for computationally demanding applications. John and his group are designing programming systems that can effectively harness the power of these new processors, and are applying their results to both traditional graphics problems such as shadow generation as well as to more general-purpose problems like numerical simulation.



VLSI Computation Laboratory

Prof. Bevan M. Baas (http://www.ece.ucdavis.edu/vcl/)

Members of the VLSI Computation Laboratory (VCL) are seeking to discover and develop novel contributions in high performance and energy efficient VLSI computation, with an emphasis on digital signal processing (DSP) workloads.

The group recently completed a fully-functional single-chip processing array containing 36 programmable processors. The architecture is called an Asynchronous Array of Simple Processors (AsAP) and was presented at ISSCC in February.

Although each processor has standard synchronous-style circuits, each of the 36 processors contains its own oscillator and is fully asynchronous with respect to all others (GALS). All inter-processor data synchronization is handled in hardware.

Each processor operates up to 475 MHz, which is believed to be the fastest processor designed in a university. On average, each processor dissipates 32 mW while executing applications. Applications include numerous DSP and general purpose kernels, a 9-processor JPEG encoder, and a 22-processor 802.11a/g wireless LAN transmitter that is fully compliant with the IEEE standard. The group recently completed a working C compiler for AsAP.

Each processor occupies 0.66 mm^2. If this exact design were scaled to a 90 nm 13mm x 13mm chip, it would contain over 1000 processors, operate at almost 1 GHz, have a peak throughput of 1.0 TeraOp/sec, and dissipate a total of 8 Watts plus leakage while executing applications.

The VCL group is now working on extensions to AsAP, high performance and efficient Low Density Parity Check (LDPC) decoders, and other DSP engines.

The group has 11 graduate students and a number of undergraduate researchers. Funding is provided by Intel Corporation, UC MICRO, grants from the National Science Foundation (NSF), and a UC Davis Faculty Research Grant.

Robust & Ubiquitous Networking (RUBINET) Research Group

http://www.ece.ucdavis.edu/rubinet/

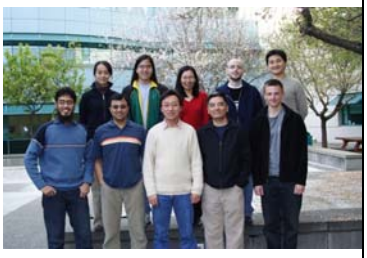
Led by Prof. Chen-Nee Chuah, the RUBINET research group strives to design network infrastructure, protocols, and techniques that are robust, secure, and efficient in the presence of failures, attacks, and uncertainty in user demands. Our approach is driven by analysis and modeling of real Internet traffic and network measurements.

As the Internet becomes an essential part of our everyday life, it has grown to a complex distributed networked system that is hard to characterize. Our group is also interested in developing foundations for measuring and validating the system behavior and end-to-end properties of the Internet.

In fact, RUBINET was among the first to conduct a thorough measurement-based characterization of network failures and routing instability, and their impact on traffic forwarding. Prof. Chuah's vision for the future is to develop a clean-slate design of a Robust, Secure, and Efficient (RoSE) Internet control plane. She received an NSF career award (2003-08) for this effort. We also seek to model the interactions between different entities as well as across multiple protocol layers/modules. In the context of wireless and mobile networking, we have prior success in leveraging both infrastructure-based and peer-to-peer connectivity to optimize the performance of multimedia streaming.

We also have working prototypes that demonstrate the feasibility of 'opportunistic network', by leveraging intermittent communication opportunities through multiple interfaces on mobile devices, as well as highly mobile networks (e.g., vehicular ad hoc networks), to provide new networking and computing paradigms.

RUBINET currently consists of five PhD students and two MS students have recently graduated from our group. The projects are funded by National Science Foundation (NSF) grants, UC Micro Programs, gifts from industrial sponsors (Hewlett Packard, Intel, and Sprint), and student fellowships (Accel, GAANN, CITRIS, and UC-Davis NRTF).



Recent Highlights:
Two recent PhD graduates: Ram Keralapura (Narus, Inc) and Danjue Li (Cisco).
New collaborative efforts
"Sampling the Internet for Effective Network Anomaly Detection" with Sprint
"Wireless Management Overlay on Mesh Networks" with Intel
New NSF CMI grant on "Distributed Vehicular Traffic Management via Vehicular Mesh Networks and Computing Grid"
Continuing NSF CAREER grant on "Robust, Secure, and Efficient (RoSE) Routing", and NSF NeTS grant on "Modeling, Validation, and Optimization of Distributed Firewalls"

Prof. G. Rick Branner

Agilent Technologies

Agilent Technologies Donation

Agilent Technologies, the world's premier measurement company, has donated approximately $200,000 in new equipment to the RF and Microwaves in Wireless Communications educational effort under the direction of Prof. G. Rick Branner. The equipment is focused primarily on undergraduate education, as exemplified by courses EEC 132 A, B, and C, entitled RF and Microwaves in Wireless Communications. The equipment will also be employed in several graduate level courses taught by Professor Rick Branner. Through generous donations such as these, Agilent Technologies continues a tradition which has afforded UC Davis and Professor Branner with state of the art instrumentation for RF and Microwave education for more than the past two decades. This has directly assisted in the training of hundreds of engineers in the fields of Applied Electromagnetics, RF, and Microwaves. The current donation certainly provides UC Davis with one of the finer RF and Microwave teaching laboratories in the country. Agilent Technologies is a technology leader in communications, electronics, chemical analysis, and life sciences.

Recent Accomplishments

Professor Baas Receives NSF Early Career Award

Prof. Bevan M. Baas

Dr. Bevan M. Baas received a CAREER award from the National Science Foundation for his proposal titled, "Processors for the Computation of Future Digital Signal Processing Applications".

The National Science Foundation's Faculty Early Career Development (CAREER) Program is a Foundation-wide activity that offers the Foundation's most prestigious awards in support of the early career-development activities of those teacher-scholars who most effectively integrate research and education within the context of the mission of their organization.

Professor Qing Zhao receives two new Multi Year NSF Awards

Prof. Zhao wins two new Multi Year NSF Awards, an exceptional feat for a young faculty member.

Professor Qing Zhao has received two new multi year NSF awards. One is entitled "Decision Theoretic Approach to Resource Constrained Cyber Infrastructure" and the second one is entitled: "Integrated Approach to Opportunistic Spectrum Access". She is the only PI on both these awards and these are each a three year grant with the first one at $240K for three years and the second at $230K level for three years. It is extraordinary and exceptional for a young faculty to receive two such grants in the same year from a peer reviewed agency like NSF. Congratulations Professor Qing Zhao.

Shining a Brighter Light

Prof. Charles E. Hunt (http://www.ece.ucdavis.edu/HuntGroup/)

New lighting technology developed at UC Davis offers quality, cost and environmental benefits compared with existing types of lighting, according to Charles E. Hunt, professor of electrical and computer engineering.

Field emission lamps can match exactly the spectrum of natural daylight, Hunt said. They are up to five times more energy efficient than existing R- and PAR-type lamps and do not contain environmentally hazardous materials, such as the mercury vapor used in fluorescent tubes, he said. They are cheaper and can produce a wider variety of colors than light-emitting diodes (LEDs). The technology could be used for indoor and outdoor area lighting, specialty applications such as film and video production, and for illuminated displays, traffic signals or technical lighting.

Field emission lamps are based on the same principle as the luminescent phosphor materials used in TV sets. Light is emitted when electrons are driven into the material. Traditional TV sets use a thermal electron gun to fire electrons into a phosphor screen. The new field emission devices use a powerful electric field to extract electrons from the cathode and drive them into the phosphor, which are located close together. The process is dramatically more efficient than the filaments used in electron guns.

"It combines 70-year-old vacuum tube technology with the latest advances in carbon nanomaterials," said Andrei Chakhovskoi, co-inventor of the device.

The UC Davis laboratory has developed materials for field emission cathodes that are inexpensive and simple to make. Lamps based on the material should have a lifetime of up to 30,000 hours, Hunt estimates.

Hunt's group is working with the California Lighting Technology Center at UC Davis and the California Energy Commission on potential applications. The technology is based on inventions at UC Davis and on a collection of patents and intellectual property donated to UC Davis in 2004 by DuPont Corporation. The university is currently negotiating agreements to license the technology for commercial development.

Prof. Emeritus S. Louis Hakimi

In Memory of S. Louis Hakimi

Chair of the Department of Electrical and Engineering from 1986 to 1996, Hakimi died last June 23 following a long illness. He was 73. Hakimi received his bachelor's, master's and doctoral degrees in electrical engineering from the University of Illinois-Urbana in 1955, 1957 and 1959, respectively. In 1986 he joined UC Davis, and retired in 2001. He was an internationally recognized expert in graph theory, which uses mathematics to understand electronic circuits and networks. His work is now widely used in designing microchips. Hakimi is survived by his wife, Mary, and three children.

Students Accomplishments:

ECE Senior Wins Best Oral Presentation at the California Alliance for Minority Participation Symposium

Bokuba Nwengela

Bokuba Nwengela, a senior at the ECE department of UC Davis was honored with a Special Award for Best Oral Presentation at the CAMP symposium (California Alliance for Minority Participation). This award was given to the best four presentations in each category (Biological Sciences, and Physical/Engineering Sciences). CAMP symposium brings together undergraduates from all eight University of California campuses to present and share their results and experience in their various fields of research. The event is sponsored by the California Alliance for Minority Participation, and is partly funded by the National Science Foundation (NSF). CAMP encourages under-represented students to participate in research activities while completing a Bachelors Degree. The students are also encouraged to embark on graduate studies. Bokuba Nwengela delivered a presentation on novel Nanoscale Transistors made with single molecules. He talked about a recent research study he performed at the Integrated Nanodevices and Systems Research Laboratory (Inano). In this study, he was able to verify the current modulation properties of special organic molecular structures, which are very promising and important to the electronics industry. Their electronic properties make them important to such applications as tunnel junctions with negative differential resistance, molecular transistors, and building blocks for basic memory networks. Furthermore, given their sizes of just a few nanometers, these devices lend themselves to ultra-fast device applications, and can offer high levels of integration.

Haitong Sun Receives Anil Jain Memorial Prize

Dr. Haitong Sun

Haitong Sun, a recent Ph.D. graduate, has been selected as winner of this years Anil Jain Memorial Prize for best Ph.D. Dissertation. Haitong completed his PhD dissertation under Dr. Zhi Ding. He came to UC Davis in the Fall of 2002 and graduated in August of 2006.

His dissertation, entitled "Transceiver Optimization for MIMO ARQ Systems," was selected by the ECE Awards Committee as the best Ph.D. Dissertation from 2005-2006.

The Anil Jain Memorial Prize was established in 1990 in honor of the late Professor Anil Jain (ECE). The Prize is awarded annually to the best PhD student dissertation in the department of ECE. The winner receives a $1000 check and a certificate.

Dr. Sun currently works as a research engineer for Qualcomm in San Diego, CA.