Everything You Ever Wanted to Know About Graduate School*

*(but were afraid to ask)*

Victor P. Nelson
Professor & Graduate Program Officer
Auburn University
Electrical and Computer Engineering

Department of Electrical and Computer Engineering
What Questions Should I Ask?

- What is graduate school?
- Why should I go?
- What degree(s) do I want?
- When should I go?
- Where should I go?
- How do I get in?
- How long will it take to finish?
- How am I going to pay for it?
- What are my opportunities in Auburn’s ECE Department?
- Where can I find more information?
What is graduate school?

- Advanced study beyond the bachelors degree
  - usually focus on a specialized area
  - build on foundation from previous study
  - many programs prepare you to do research

- “Professional” schools prepare for practice of a specific profession
  - law, medicine, dentistry, pharmacy
Why should I go to grad school?

• **Career/Vocational Goals** (*Study the market!*)
  – Does the job require an advanced degree?
  – improve/update skills & marketability
  – change careers (mobility)
  – higher salary/greater potential for advancement

• **Personal fulfillment**
  – love of the field
  – satisfy intellectual curiosity
  – the challenge of mastering a field

• **Postpone facing the “real world”??**
What degree(s) do I want?

- **Masters Degree**
  - higher starting salary
  - increased responsibility (immediate impact)
  - thesis (research) vs. non-thesis options

- **Doctoral Degree**
  - requires a research dissertation
  - needed for university faculty
  - research-oriented company/agency

- **Master of Business Administration (M.B.A.)**
  - if interested in engineering management

- **Professional Degree**: law, medicine, etc.
Graduate Degrees in ECE at Auburn University

- **Master of Science (MS)**
  - Requires coursework, research & thesis

- **Master of Electrical Engineering (MEE)**
  - Requires coursework & project (non-thesis)

- **Doctor of Philosophy (PhD)**
  - Requires publishable research & dissertation
Starting salaries for engineering

### Electrical and Computer Engineering

- **BS**: ECE $51,124
- **MS**: ECE $64,413
- **PHD**: ECE $73,674
Average salaries in engineering and related fields
Where should I go?

• First decide what you want to study
  – “electrical engineering” is too general
  – more specific: “wireless network security”
• Research the school’s reputation/activity in your technical interest area
  – number of professors in that area
  – publications & research funding in that area
  – courses taught in that area
  – research facilities, computing labs, library
  – industrial partnerships
  – who hires the graduates
Other considerations

• Availability of financial assistance
• Level of faculty/student interaction
• Degree requirements (credit hours, thesis vs. non-thesis, time to completion)
• Other – geographic location, extracurricular activities, cost of living, size of school
• Multiple degrees from the same school?
  – grad courses build on lower-level courses
  – different schools provide different perspectives

• Apply to several schools!
When should I go?

• **Right after bachelors degree?**
  – have academic “momentum” and discipline
  – fewer responsibilities when younger
  – improve marketability for first job
  – hard to give up a job later to return to school

• **After gaining work experience?**
  – work experience provides more perspective
    • better understanding of your field
    • learn what problems need to be solved/researched
  – may be “burned out” after 16+ years of school
  – can save money for school and/or pay off debts
  – possibly get employer to pay for school
How do I get in?

- **Request materials** (indicate desired program)
- **Submit application and fee**
- **Other items you may be asked to provide:**
  - Official transcripts (have your registrar send them)
  - Graduate Record Exam (GRE) scores
  - Letters of recommendation
    - address your skills, dedication, accomplishments, potential
  - A “statement of purpose”
    - explain your area of interest, experience, reason for applying
  - Your resume
What is the admissions committee looking for?

• **Evidence of academic potential**
  – grades* - especially in math, science and engineering courses
  – reputation of school(s) attended
  – GRE scores*
  
  *some departments require minimum GPA/GRE

• **Motivation for graduate study**
  – statement of purpose
  – recommendation letters
  – other scholarly activity (undergrad research, etc.)

• **Background** (areas of previous study)
Auburn ECE Masters Program Entrance Requirements

• B.S. degree in ECE or closely-related field from an accredited program
• GPA of accepted applicants usually > 3.0 (lower GPAs can be offset by outstanding GRE scores and/or recommendation letters)
• GRE general test
• TOEFL exam (international applicants)
Graduate school entrance tests

- **GRE** – engineering & most other disciplines
  - General test has verbal, quantitative, and writing sections (V/Q scored 200-800 on each section, W scored 1-7)
  - Some schools may require a “subject test”
  - [www.gre.org](http://www.gre.org) for test dates/places/info

- **TOEFL** – required for international applicants (some take IELTS – *Int’l English Lang. Test Syst.*)

- **Professional/business schools** (instead of GRE)
  - **GMAT** for Business School
  - **LSAT** for Law School
  - **MCAT** for Medical School
How long will it take?

• “It depends...”
  – degree requirements
  – work responsibilities (assistantship, job)
  – availability of courses
  – time for thesis/dissertation research and writing
  – your level of dedication

• Time to complete a masters degree
  – typical time about 2 years if doing a thesis
  – non-thesis programs can take less time if student takes a full load every semester

• Doctoral degree typically 3-5 years
  – depends on time to research and write a dissertation
Masters degree requirements

• Typically about 30 semester credit hours
  – might require a set of “core” courses (plus electives)
  – might be entirely elective

• Thesis option:
  – identify a problem, conduct research, write the thesis
  – usually have a final oral exam to “defend” the thesis

• Non-thesis option:
  – might require coursework only
  – might require a “project”
  – often requires a comprehensive exam (oral and/or written)
Auburn ECE Masters Degree Requirements

• 30-33 credits of 6000/7000 course work
  – at least 21 credits in ECE & 24 credits at Auburn
  – at least one course in each of three ECE areas
• M.S. degree (30 credits) includes:
  – 4 to 6 hours of research & thesis (ELEC 7990)
  – final oral exam, defending the thesis
• M.E.E. degree (33 credits) includes:
  – 3-credit project (ELEC 7980)
  – written and oral project reports serve as the final exam
  (“Thesis” is published, “Project” report is not)
How am I going to pay for it?

- **Graduate assistantship** – receive stipend/tuition for work in the department
  - Teaching (conduct labs, grade papers, etc.)
  - Research
- **Fellowships** (university or external)
  - Often grants not tied to specific work obligations
- **Loans** (use wisely – consider level of personal debt)
- **Outside employment**
- **Employer-sponsored**
Cost of Graduate School (A.U.)

- **Estimated cost per semester** (Fall 2005-Summer 2006)
  - **Alabama resident**: Total cost = $8,355*
    - tuition & fees only = $2,807
  - **Non-resident**: Total cost = $13,155*
    - tuition & fees only = $7,607
  
  * Total cost = tuition, fees, living expenses, insurance, etc.

- **GTA/GRA appointments (of at least 1/4 time)** include a “tuition fellowship”
  - Graduate School pays tuition for up to 40 credit hours for masters students on GTA/GRA
  - Beyond 40 credit hours, all GTAs/GRAs are eligible for the in-state tuition rate
Graduate teaching assistants

- GTAs assist with undergraduate instruction
  - laboratory sessions, grading homework
  - occasionally teach lecture courses
- Stipend usually depends on work load
  - number of courses taught, grading assignment, etc.
  - Example: ¼ time = $615/month (1st year masters)
- Many schools provide GTA’s with waivers of tuition or reduced rates
  - Auburn now pays up to 40 credits of tuition for GTAs with at least 25% appointment
Graduate research assistants

• GRAs assist faculty in research activities
  – GRA research often the basis for the thesis or dissertation
  – Usually appointed by faculty with funded projects

• Stipend depends on the assigned work load
  – Example: 1/3 time = $1078/month (1st yr. M.S.)

• Many schools provide GRAs with a waiver of tuition, or a discounted rate
  – Auburn now provides 40 credits of tuition for GRAs with at least 25% appointment
Auburn University
Electrical & Computer Engineering
Graduate Research Activities

Department of Electrical and Computer Engineering
ECE Graduate Enrollment
(Fall semesters, 1981-2005)
The ECE “Stems”

Electronics:
- microelectronics, amplifiers, analog, digital, and RF integrated circuits, MEMS …

Digital Signal Processing & Communications:
- massage of complex electrical signals for information extraction, compression, correction …

Wireless:
- wired and wireless data transmission, signal modulation, coding theory, information theory …

Automatic Control Systems:
- electronic feedback techniques for process control, motor control, aerodynamics …

Electromagnetics:
- generation and reception of electromagnetic waves, antennas, lasers, radar …

Power Engineering:
- generation, transmission, distribution of electricity for commercial and residential …

Logic & Computing Devices:
- architecture, VLSI design, testing, hardware, and software for computers and peripherals …

Circuits & Systems:
- basic electrical circuit network theory, analysis of electrical signals …
ECE Major Research Focus Areas

- MEMS (MicroElectroMechanical Systems)
- SiGe (Silicon-Germanium)
- VLSI Design and Test
- NanoTechnology
- Embedded Systems
- High-Performance Computing
- Electric Power Engineering
- Electronic Packaging
Major Research Focus Areas (Wireless Engineering)

- Networks
- Signal Processing
- Security
- Telecommunications
- Smart Antennas
- Transceiver Design
ECE Research Expenditures Per Faculty Member

ECE - Funded Research Expenditures per Full Time Faculty Member

$0 $20,000 $40,000 $60,000 $80,000 $100,000 $120,000 $140,000 $160,000 $180,000

ECE Research Sponsors

**Government**
- AFOSR
- ARO
- DARPA
- DOE
- NASA
- NIH
- NSF
- ONR
- Sandia National Labs

**Industry**
- Diamler/Chrysler
- Henkel
- IBM
- Motorola
- Northrup/Grumman
- Semiconductor Research Corp.
- Southern Company
- Texas Instruments
- Whirlpool Corporation
ECE Graduate Faculty

• 32 faculty loosely organized into 7 “stems”
  – Communications & signal processing
  – Control systems
  – Digital systems & computer engineering
  – Electromagnetic modeling & analysis
  – Microelectronics
  – Power systems
  – Wireless engineering
Named Professorships in ECE

- Prathima Agrawal, Sam Ginn Distinguished Professor
- Vishwani Agrawal, James J. Danaher Professor
- Charles Gross, Square-D Power Professor
- Mark Halpin, Alabama Power Distinguished Professor
- J. David Irwin, Earle C. Williams Eminent Scholar
- Richard Jaeger, Distinguished University Professor
- R. Wayne Johnson, Information Technology Peak Dir.
- Adit D. Singh, James B. Davis Professor
- Jitendra Tugnait, James B. Davis & Alumni Professor
- Bogdan M. Wilamowski, AMSTC Director
IEEE Fellows

- Prathima Agrawal
- Vishwani Agrawal
- Mark Halpin
- J. David Irwin
- Richard C. Jaeger
- R. Wayne Johnson
- R. Mark Nelms
- S. M. Rao
- Adit D. Singh
- Charles Stroud
- Jitendra K. Tugnait
- Yonhua (Tommy) Tzeng
- Bogdan M. Wilamowski
ECE Faculty
National/International Awards

- Eta Kappa Nu National Outstanding Teacher Award
- (2) IEEE Undergraduate Teaching Award
- (2) IEEE Power Engineering Outstanding Educator Awards
- (2) IEEE McGraw Hill/Jacob Millman Awards
- (4) IEEE Third Millenium Medals
- (2) International Microelectronics and Packaging Society Technical Achievement Awards
- IEEE Computer Society Outstanding Contribution Award
- IEEE Richard M. Emberson Award
- (13) IEEE Fellows
ECE Faculty Scholarship & Professional Service

- Editors of International Journals—11
- Associate Editors of International Journals—40
- Books Published—38
- Book Chapters Published—32
- Patents—122
- Average Journal Papers Published/Faculty/Year—2
- Presidents of Technical Societies—10
- Chairs of Technical Conferences—40
- Technical Society Governing Board/AdCom Positions—31
VLSI Testing & Design
(Pr. Adit Singh & Vishwani Agrawal)

• High performance VLSI Design
• Design for testability
• Test generation
• Defect based testing
• Test optimization strategies
• On-line testing
• VLSI reliability and defect-tolerance
Low-Power Design  
(Vishwani Agrawal)

• Problem: Design digital circuits that consume minimum dynamic power; unnecessary dynamic power is consumed by non-functional glitches in signals.

• Solution:
  – A linear programming method removes all power-consuming glitches by readjusting gate delays.
  – New differential input-delay CMOS logic implements the readjusted delays.
  – Result: 50-60% reduction in dynamic power.
Built-In Self-Test  
(Prof. Charles Stroud)

• What is BIST?
  – Designing circuits to test themselves
    • Designing circuits to diagnose themselves

• Current Projects:
  – BIST for Field Programmable Gate Arrays
    • Funded by National Security Agency $95K/year
    • Funded by Space & Missile Defense Command $100K
      – produced 8 patents (5 more pending) and 38 publications
  – BIST for Mixed-Signal Systems
    • Funding pending
      – produced 2 patents (both pending) and 10 publications
An FPGA consists of:

- A configuration memory
- An array of programmable:
  - Logic blocks
  - Interconnect
  - I/O Cells

Writing the configuration memory programs FPGA

- Can perform any digital function
  - Changing configuration memory data changes system function

Typical complexity = 5M – 100M transistors

- All transistors must work for a fault-free FPGA
BIST for FPGAs

• **Basic idea:** reprogram FPGA to test itself
• Program logic blocks to function as
  – Test Pattern Generators (TPGs)
  – Output Response Analyzers (ORAs)
  – Blocks Under Test (BUTs)
    • Reverse rolls after test 1st set of BUTs
• When faults are detected:
  – Reprogram FPGA to diagnose itself
  – Reprogram system to avoid faults
Digital BIST circuitry tests analog circuits without impact to analog circuit performance.
Power and Energy
(Prof’s Gross, Nelms, Halpin)

• Research areas
  – Power systems, power electronics, energy conversion

• Current research activities
  – Radar power technology (Nelms)
    • Sponsor – U.S. Army Space and Missile Defense Command
    • Participants – AU, University of Mississippi, Mississippi State Univ.
  – Power quality (Halpin)
    • Sponsor – Southern Company/Alabama Power
  – Electric vehicle drives and wind machines (Gross)
Capacitor charging power supply line manufactured and marketed by Maxwell Technologies, Inc., San Diego (division sold to General Atomics in 2000)

First commercial product from the NASA CCDS program

First ever demonstration of a solid-state T/R radar module powered by a fuel cell

Joint demonstration at the University of Mississippi with AU research team
Dr. Hulya Kirkici  
RESEARCH AREAS:  

- **High Voltage Engineering**: This is a research area to understand and engineer electrical insulation in high voltage and high power devices and systems. Most applicable areas are in utility power industry. However, high voltage engineering is applicable to disciplines from microelectronics industry to space power systems.

Surface Flashover Research on Advanced Materials to be Used in Space
Dr. Hulya Kirkici
RESEARCH AREAS:

**Pulsed Power Engineering:** The area of pulsed power research involves storing, shaping, transmitting, and measuring high voltage, high current pulses of electrical energy. This is important to many applications areas, such as laser drivers, high power microwave generators, particle accelerators, materials processing, waste and product sterilization, and food purification, industrial manufacturing technology, and electromagnetic mass drivers.

**Electro-Optics:**
- Research in lasers and high power/efficiency light sources. Development of UV plasma (light) for Environmental/Surface Cleaning & Pollution Control and industrial use.
- Developing optical spectroscopic measurement techniques in these related fields.
Picture of a hollow-cathode plasma device to be used as a UV source

Dr. Hulya Kirkici

### Laser Oscillator

- Optical gain is achieved when stimulated emission exceeds absorption
- This occurs when we have a POPULATION INVERSION
- Optical gain can be converted into optical oscillation by means of feedback
- This is done using mirrors
• Spectroscopic imaging can split a standard MRI into components that image specific biochemicals.
• The water and fat components of the top image are shown in the two lower images.
Resolution Improvement  
(Prof. S. J. Reeves)

• The component images are generally blurry due to the long imaging times required (shown at left).

• Our new image processing technique allows us to sharpen the components (right) by combining them with the original MRI.
- Applying image processing and computer vision technology to cardiac MRI

- Will allow more accurate diagnosis and treatment of heart attacks
Image Processing – Contraction of the Human Left Ventricle Measured with MRI

Purple/Blue: contraction
Red: no contraction

Heart tissue permanently damaged after a heart attack.

Normal  After a Heart Attack

Research Supported by:

Prof. T. S. Denney
RFID Devices

(Prof. Stuart M. Wentworth)

- Target life of 1 month
- Target cost < 5 cents
- Target sensitivity tens of cells
- Communicates by radio frequency, non line of sight
- Goal: place a Stag (Sensor Tag) on appropriate fresh food products
- Measures temperature, bacteria count, other chemical changes
- Stores information for traceability such as origin, date & time of processing, shipment
Software Radio and Wireless Networks for Cooperative Robotics – Dr. Thad Roppel

Software Radio RF Transmitter Assembly

Wireless Rover development

Stationary and mobile robots cooperating with humans over long distances for space exploration.
RF Transmitter Assembly
(Dr. Roppel)
Mine Discrimination System Developed By Dr. Riggs and His Research Team for the Army Research Office
Mine Detection
(Prof. L. S. Riggs)

Close Up of Back Pack Mounted Electronics - Discrimination Capability Helps Reduce False Alarms - In Humanitarian Demining Missions Approximately One Mine Is Removed for Every 1000 False Alarms (Metallic Junk)
Wireless Network Security
(Prof. C. “John” Wu)

• Algorithms for end-to-end security for wireless services in 3G networks and wireless local area networks
  – Authentication and access control for roaming devices
• Intrusion Prevention System
• Denial of service attack prevention
• Network-based control system security
QOS in IP Mobile Networks
(Prof. C. “John” Wu)

• Algorithms for Quality of Service (QOS) in IP-based mobile networks
  – 3G networks and wireless local area networks
  – QOS for Voice/video communications
  – Optimal distributed control of wireless network resources

• Crucial for the performance of large-scale 3G data/voice/video networks
High Performance Computing
(Prof. Soo-Young Lee)

- Heterogeneous computing systems
  - Load balancing
  - Scheduling
  - Parallelization of large-scale applications
- Heterogeneous communication networks
  - Source rate control
  - Path selection, Multi-path communication
- Sensor networks
  - On-off/range control
  - Security, Applications
Electron-beam Proximity Correction
(Prof. Soo-Young Lee)

- E-beam Lithography
  - Transfer fine-feature patterns onto substrates
- Proximity Effect
  - Pattern “blurring” due to electron scattering
- Correction
  - Spatial dose control
  - Feature shape modification
- Experimental results
  - Minimum feature size: 100 nm
  - Shape modification
**Main Focus:**
- Advanced receiver algorithms for improved signal detection in DS-CDMA (direct sequence code division multiple access) systems to increase system capacity.

**Other Issues Under Investigation:**
- Modeling of time-varying communication channel characteristics (to account for multipath propagation and mobile motion)
- Physical layer issues in peer-to-peer packet radio:
  - ad hoc networks: no base station
  - no power control
  - user detection/authentication
- Spread spectrum CDMA techniques for multirate signals (voice, video and data) for multimedia applications
Multiuser Detection (MUD) of DS-CDMA Signals (Prof. J. Tugnait)

- All users transmit simultaneously over the same frequency band. Multiuser interference (other users’ signals) limit the system capacity.
- System capacity (number of users that can be accommodated simultaneously) in a given cell is governed by the spreading factor (processing gain).
- Conventional techniques (code matched filtering) treat other users’ signals as noise.
- Conventional techniques are near-far sensitive (have trouble detecting weak power users): need power control.
- MUD approaches are near-far resistant. They *model* the other users’ signal.
Who to talk to:
- Greene (avionics/aerospace sensing and control, embedded control)
- Hodel (NASA Space Launch initiative, MEMS devices)
- Hung (control of vehicles, robots, power electronics)
Control Systems

• What is control systems about?
  – Make things behave how we want - not how they behave “naturally”
  – Example: the Wright brothers did not invent flight, they invented flight control!

• What goes with that?
  – Very multidisciplinary - work with mechanical, aerospace, civil, materials, and most of the EE subdisciplines!
  – Controls is often the “magic” that makes a project succeed (or fail)!
Example Projects

- UAV platforms
  - Goal: Fly low (2m from ground) with no pilot involved - want to detect mines!
- MEMS device control
The X-33 is gone, but NASA is still working on the next generation launch vehicle, and Auburn is a part of it! (US citizens only)
Summary

- Requires hardware: sensing (to “see” the environment) and actuation (what makes it move)
- Requires number crunching software written by ECE’s
  - keep track of position, velocity, desired trajectory
  - Recognize vehicle limits
  - Send commands to actuators
  - “Guarantee” stability and performance - even if something goes wrong (such as an engine failure)
AMSTC
Alabama Microelectronics Science and Technology Center

Richard C. Jaeger
Bodgan M. Wilamowski

Department of Electrical and Computer Engineering
• History:
  - ECE Microelectronics Laboratory established in 1974
  - AMSTC founded in 1984

• Mission Statement:

  “To advance microelectronics science, technology, and education by providing facilities which encourage interdisciplinary research and educational activities within Auburn University and the State of Alabama.”
## Participating Laboratories

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<tr>
<th>Laboratory</th>
<th>Dept.</th>
<th>Lab Director</th>
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<td>Microelectronics Fabrication</td>
<td>ECE</td>
<td>C. D. Ellis</td>
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<tr>
<td>Electronic Materials Processing</td>
<td>ECE</td>
<td>Y. Tzeng</td>
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<tr>
<td>Experimental and Computational Mechanics Laboratory</td>
<td>ME</td>
<td>J. C. Suhling</td>
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<tr>
<td>Enhanced Heat Transfer Laboratory</td>
<td>ME</td>
<td>S. H. Bhavnani</td>
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<tr>
<td>SiGe Device Characterization</td>
<td>ECE</td>
<td>Guofu Niu</td>
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<tr>
<td>VLSI Design and Test</td>
<td>ECE</td>
<td>A. D. Singh</td>
</tr>
<tr>
<td>Surface Science Laboratory</td>
<td>Physics</td>
<td>Michael Bozack</td>
</tr>
<tr>
<td>Laboratory for Electronics Assembly and Packaging (LEAP)</td>
<td>ECE</td>
<td>R. Wayne Johnson</td>
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AMSTC Funding

The AMSTC facilities and research are supported by a baseline funding of approximately $300,000/yr from the College of Engineering as well as research contracts and grants funded by industry and government agencies. In FY2002, total AMSTC research expenditures were $2.93M.

The AMSTC was the first center to perform truly interdisciplinary research within the college and involves personnel and facilities from Electrical and Computer Engineering, Mechanical Engineering and Physics. Cooperating researchers include faculty from Materials Engineering, Chemistry and Veterinary Medicine.
Active Research Areas

- Defect Based Testing
- Electro-Explosive Device
- Wireless Circuit Design
- Diamond Film Deposition
- Carbon Nanotubes
- Piezoresistive Stress Sensor
- High Heat Flux Applications,
- Silicon Carbide Device Design
- MEMS structures and Devices
- Computational Intelligence
Active participants in AMSTC activities during FY2002 included 15 faculty members, 4 staff, 3 co-op students, and 20 graduate students.
With funding from an NSF grant and internal Auburn grants, the microelectronics laboratory of AMSTC has added two STS reactive ion etching systems (one for Advanced Oxide Etching and the second for Advanced Silicon (and SiC) Etching), a double-sided mask aligner (MA-6), and a metal deposition system with an ion gun, sputtering target and two e-guns (CHA MARK 50).

The investment of approximately $1.1M in new equipment gives AMSTC state-of-the-art MEMS fabrication capability.
MEMS Sensors And Actuators

MEMS Accelerometer

- Cantilever Beam Accelerometer
- Supporting Litton
- Etched at Auburn

AMSTC
The AMSTC has also supported the micro-mirror fabrication efforts of MEMS Optical in Huntsville.

325 micromirrors on a 15 x 15 mm² chip (Mems-Optical)
MEMS

- Micro Mirror Chip
- MEMs Optical (Huntsville)
- 325 Mirrors Supported by 4 Metallic Springs
- 700 x 700 mil die

Single Mirror

AMSTC
Optical MEMS

Over the past three years, the AMSTC fabrication capability has been used to fabricate various MEMS devices with application in optical signal communication. These include an “inch-worm” driven platform for optical mirrors, and shutter arrays for optical switching.
RF MEMS

Professor Ramesh Ramadoss has just recently been hired as a new faculty member in Electrical and Computer Engineering. Professor Ramadoss, an expert in MEMS Design, modeling and fabrication, will be continuing his research in the following areas:

- RF MEMS Switches and their applications in wireless systems
- Circuit Applications of RF MEMS devices such as Phase shifters, filters etc.
- RF MEMS based Reconfigurable Phased array antenna systems

RF MEMS Devices using flexible printed circuit technology
RF MEMS Devices using Flexible Printed Circuit Technology

Advantage: Batch fabrication of these type of switches can be carried out using existing roll-to-roll printed circuit technology

Application: Batch integration of these switches with printed circuits and antennas (on rigid or flexible substrates) over large areas for reconfigurable wireless communication systems
Miniature flexible electrical probes have been designed and fabricated at AMSTC laboratory.

The probe allows cardiac electrical impedance measurements in a moving heart muscle.

The probes have been tested on rabbit hearts at The University of Alabama at Birmingham’s Cardiac Measurement Laboratory, and have been found to perform as well as the rigid probes previously used with the added benefit of minimal tissue damage due to its size and flexibility.

A strain relieving design technique increases the reliability of the probes.
Defect Based Testing

Professor Singh’s group is developing new design-for-test techniques to increase the effectiveness and efficiency of timing tests, and the work has resulted in several publications and two patents. The patent on a new high performance design-for-test technique has already been licensed to a major microelectronics manufacturer. The research effort is now exploring new areas essential for the test and verification of the high performance digital and RF analog circuits with Professors Stroud, Dai and Jaeger.

Adit Singh
Vic Nelson
Chuck Stroud
Richard Jaeger (VLSI and testing)
Foster Dai (VLSI and testing)
Vishwani Agrawal
Electro-Explosive Devices

Professor T. A. Baginski

- The Reactive Bridge
- Novel Solid-State Ignite
- Patented Technology

- Licensed to Largest Japanese Airbag Initiator Manufacturer (Nippon Kayaku)

- Licensed to Largest U.S. Manufacturer of Initiators for Aerospace/Government Applications (Pacific Scientific)
• Structure employs laminations of Ti/B

• Exothermic inter-metallic alloy

• No oxidizer required

• \(2B + Ti \Rightarrow 1320\text{cal/gm}\)
Electro-Explosive Devices

• Test Firing of Structure (creates super-heated cone of Ti/B droplets

• Presently in Pre-production development for introduction as “Smart Airbag Initiator” (anticipated commercial introduction 2007 Model Year)

• Successfully Flight Tested in Compact Kinetic Energy Missile attitude control system (May 2003)

4cm
SiGe Device Design
Guofu Niu

- Optimization of high-speed SiGe HBTs and CMOS for wireless and optical networking integrated circuits (NSF, SRC, IBM, Intel, NASA)

<table>
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<th>GPS handset</th>
<th>GPS receiver chip</th>
<th>70GHz SiGe HBT</th>
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Silicon-Germanium HBT Technology for RF/Wireless

- Atomically engineer Si transistors for high-speed at low cost
- 100 GHz performance in a CMOS compatible RF technology!
Research Activities
(Prof. Guofu Niu)

- Frequency scalable RF front-end design (IBM)
- Technology computer-aided design of integrated RF transistors and passives (NSF)
- Fabrication and design of SiC power MOSFET (DoE-ORNL)
- RF CMOS (90nm and below)
Analog Circuit Design Research (Prof. Foster Dai)

- Ultra high speed Direct-Digital Synthesis (DDS) MMIC Design
  - Applications in next generation wireless and radar
  - Low power SiGe device at a clock frequency of 12MHz
  - Supported by U.S. Army

- Wireless LAN Transceiver RFIC Design
  - Low noise amplifiers, power amplifiers, mixers, VCOs, PLLs and synthesizers are being designed
  - Synthesizer fabricated in IBM

- Mixed signal automatic Built-in-Self-Test
  - For detecting faults and for characterization and calibration during manufacturing and field testing
Diamond Films and Carbon Nanotubes
Y. Tzeng

Single-wall Carbon Nanotubes

Multi-wall Carbon Nanotubes
Vertically aligned carbon nanotubes grown at the bottom of etched holes in a silicon wafer

Horizontally aligned carbon nanotubes grown on the sidewalls of etched holes in a silicon wafer
Diamond Films and Carbon Nanotubes
Y. Tzeng

Diamond Films Deposited by Plasma Enhanced CVD

Microcrystalline 
CVD Diamond Film

Nanocrystalline 
CVD Diamond Film
The anti-Salmonella rabbit IgG immobilization on hydrophilic ND and bacterial binding (4,000 X).
MEMS Technology for Transducers and RF Communications

In this laboratory directed by Professor J. C. Suhling, we explore a wide variety of stress sensor applications in electronic packaging. We have demonstrated that it is possible to make high quality stress measurements with piezoresistive-based IC stress sensor chips. These experimental data are correlated with the results of finite element simulation. Good values of the mechanical properties are required for these simulations and these properties must often be measured within this laboratory.
Their ongoing work focuses on piezoresistive stress sensor application and development of improved resistive and active device sensors on both the (100) and (111) silicon surfaces. New techniques have been developed that permit measurement of the piezoresistive coefficients from individual die. Dynamic performance of the sensors is now being investigated, and new sensor chips are being developed to simplify application of the stress test chips.
Silicon stress sensors

Jeff Suhling
Richard Jaeger
Bodgan Wilamowski

- Complete Stress State Sensors on (111) Silicon
- Wire Bond And Flip Chip Versions
- SRC Funding
- Supplying Sensor Chips to Industry

10 mm x 10 mm Die Image
Wire Bond Version
Wireless Engineering Research and Education Center - WEREC

• Undergraduate Education – BWE
  – ECE Emphasis, Laboratory Experience
  – CSSE Emphasis

• Graduate Education and Research
  – Wireless Course Development
  – MS and PhD Research Programs

• Extension Activities
  – Short Courses
  – Video Course Materials
  – WWW

• Industrial Advisory Board
WEREC – Faculty Expertise

- Solid-State Materials – Tzeng (ECE), Williams (PS)
- RF Devices & TCAD – Niu (ECE)
- RF Circuit Design – Jaeger (ECE), Niu (ECE)
- RF Systems Design – Roppel, Rao, Riggs (ECE)
- EMC, Propagation, Antennas – Wentworth, Rao, Riggs (ECE)
- Communication Systems & Signal Processing – Tugnait, Reeves, Ma (ECE)
- Wireless Networks – P. Agrawal, Chapman (CSSE), Wu (ECE), Lee (ECE)
- Reliable Computer Systems – Nelson (ECE), Lee (ECE), Carlisle (CSSE)
- Systems Software Development – Chapman (CSSE), Lim (CSSE)
- Reconfigurable Systems – Chapman (CSSE), Nelson (ECE), Carlisle (CSSE)
- Wireless Data Security: Wu (ECE), Chapman (CSSE)
- Coding Theory – Leonard (DSS)
- VLSI Design and Testability – Singh, V. Agrawal, Jaeger, Stroud, Nelson (ECE)
- Electronic Packaging – Johnson (ECE), Suhling (ME), Jaeger (ECE)
- Business – TBD
Center for Advanced Vehicle Electronics (CAVE)

Jeffrey C. Suhling  
Director

A National Science Foundation Industry/University Cooperative Research Center (I/UCRC)

Department of Electrical and Computer Engineering
CAVE Objective

- To provide a mechanism for research and development to support advanced electronics in vehicle and other harsh environments.
  - Center to include electronics manufacturers, component suppliers, materials suppliers, equipment suppliers and academia to provide an integrated approach to R&D.
Current CAVE Members

- DaimlerChrysler
  - OEM
- U.S. Army Aviation and Missile Command & TACOM
  - System user
- Eaton Corp.
  - OEM
- Photocircuits
  - PWB
- STMicroelectronics
  - Semiconductors
- Cookson Electronics
  - Materials & equipment
- Loctite
  - Materials
- Philips
  - Modules & equipment
- Futaba
  - Displays
- Yazaki
  - Connectors
- Molex
  - Connectors
- Thermoset
  - Materials
Primary CAVE Facilities

• SMT/Flip Chip Line
• Wire Bonding
• Environmental Testing
• Surface Sciences
• Material Properties
• Modeling
Current CAVE Projects

- BGA Packaging Processing, Materials & Reliability
- Flip Chip Processing, Materials & Reliability
- Lead-free Solders Processing, Materials & Reliability
- High Temperature Electronics Packaging
- Connectors
- Relationship between ALT and Field Life
- Heat Shielding of Temperature Sensitive Components for Reflow Soldering
- Modeling Defects and Causes in Electronics Manufacturing
Non-Consortium CAVE Projects

- MEMS Packaging
  - LCP Near-Hermetic Packaging
  - Fabrication and Assembly Strategies to Minimize Vibration and Shock Sensitivity in MEMS Sensors
  - Low-Cost, High Precision MEMS Accelerometer Fabricated in Laminate
  - Manufacturing Techniques for Realizing Integrated MEMS/ MOEMS Systems
  - Vacuum Packaging Equipment Purchase
  - Missile Health Monitoring System
  - 3-D Accelerometer Packaging
Graduate School Application
Time Table

• During undergraduate studies, consider participating in a research project with faculty/grad students

• Junior year – begin investigating
  – browse guides, catalogs, web sites
  – talk to faculty, friends
  – sign up for GRE and/or other entrance tests

• September/October of senior year
  – take GRE and/or other tests
  – write statement of purpose
  – request recommendation letters from faculty

(continued)
Graduate School Application
Time Table (continued)

• November/December
  (applications typically due in December/January)
  – submit applications (on-line or mailed)
  – order official transcripts from Registrar’s Office
  – apply for fellowships, grants, assistantships

• January/March – ask about visiting and/or interviews

• March/April – consider acceptances, rejections and career options

• August/September – Get to work!
Where can I find information?

- **Informal Sources:**
  - Your professors
  - Academic advisor or college career center
  - Current grad students (email or web pages)
  - Friends who have gone to graduate school
  - Department web sites & university bulletins
  - Education resources on engineering professional society web sites (IEEE, ASME, ASCE, AIChE, IIE, AIAA, etc.)
World-Wide Web Resources

- Peterson’s guides: [www.petersons.com](http://www.petersons.com)
- GradSchools.com: [www.gradschools.com](http://www.gradschools.com)
- GradView: [www.gradview.com](http://www.gradview.com)
- American Society of Engineering Education (ASEE) [www.asee.org](http://www.asee.org) – profiles of colleges/universities
- GradNet ([www.gradnet.iec.org](http://www.gradnet.iec.org))
- ACM Graduate Assistantship Directory ([info.acm.org/gad/](http://info.acm.org/gad/))
- Government agency & private foundation web sites (fellowship information)
Questions?

For a copy of this presentation, email: nelsovp@auburn.edu