Integrated Circuits and Systems

ELECTRONICS
ARIZONA STATE UNIVERSITY
ELECTRICAL ENGINEERING DEPARTMENT

Dr. John Brunhaver
OUTLINE

- What are the focus areas in the circuits specialization and who are the faculty?
- What are the applications for circuits and the research that we do at ASU?
- How do you engage as an undergraduate in research at ASU?
- Where do “circuits” designers find jobs?
AREAS

- Analog Circuit Design
- Digital & VLSI Circuits
- MicroElectroMechanical System (MEMS)
- Emerging Devices and Circuits
- RF and Microwave IC’s
- VSLI & Digital: John Brunhaver, Kevin Cao, Larry Clark, Umit Ogras, Jae-Sun Seo
- Analog: Bertan Bakkaloglu, Sayfe Kiaei, Sule Ozev
- Emerging Devices and Circuits: David Allee, Hugh Barnaby, Shimeng Yu
- MEMS & BioEngineering: Junseok Chae, Jennifer Blain Christen
- RF & Microwave ICs: Sayfe Kiaei, Jennifer Kitchen, Georgios Trichopoulos
New Faculty – Past 2 Years

- Shimeng Yu
- John Brunhaver
- Georgios Trichopoulos
APPLICATIONS

Integrated Power Management ICs

Wireless

Security

Aerospace & Automotive

Bio-Technologies
These are your core classes for circuits.

**Analog Courses**
- EEE 433 Analog Circuits
- EEE 523 Analog CMOS

**Digital Courses**
- EEE 425 Digital Circuits
- EEE 525 VLSI

**Digital Courses**
- EEE 333 – VHDL
  - EEE 334 – Circuits I
  - EE E335 Circuits II

**Analog Courses**
- EEE 433 Analog Circuits
- EEE 523 Analog CMOS

**Advanced Courses**
- EEE 527 A/D
  - EEE 524 RFIC
  - EEE 524 Switch Cap

- EEE 598 ΣΔ Converters
  - EEE 598 Switch Cap

- EEE 598 Bioelectronics

- EEE 538 MEMS
  - EEE 598 Adv. MEMS

- CSE/EEE 518 Synthesis
  - EEE 598 Modeling

- EEE 625 Adv. VLSI
  - EEE 526 VLSI Architecture
Flexible Display Center at ASU
http://flexdisplay.asu.edu

Design Flow:

**Thin Film Transistor Characterization**
- Semiconductor Parameter Analyzer
- Automatic and Manual Probing

**Thin Film Transistor Model Parameter Extraction**
- Transistor Model Parameters Extracted from Device Data

**Improved Thin Film Transistor Models**
- Better Modeling of Parasitics
- Incorporation of Threshold Voltage Shift
- Advanced Models Enable Accurate Prediction of Circuit Performance Before Fabrication

**Circuit Design & Simulation**
- Professional CAD Suite
- Tanner Tools

**Circuit Layout & Verification**
- FDC Developing Design Rules for High Manufacturing Yield

**Fabrication & Test**

Designs in Collaboration with UDC, Honeywell, Kent Displays, and E ink.
**RADIATION - RESEARCH**

- Space Electronics and Radiation Effects
  - Space Electronics Testbed

- Reliability and Radiation Effects Modeling
- Radiation Sensors

- Extreme Environment Effects in Devices and ICs
  - Combined Temperature and Radiation for Moon/Mars
  - Low Dose Rate Effects
EMERGING DEVICES AND CIRCUITS:

3D Memory Array

Artificial Synapse

- Resistive Random Access Memory (RRAM) Technology
  - 3D integration of RRAM, RRAM array and architecture design, radiation effects on RRAM, etc
- Brain-inspired Neuromorphic Computing with Synaptic Devices
- Hardware Security with Physical Unclonable Functions
VLSI RESEARCH

- Radiation hardened VLSI circuits
- Low power/high performance microprocessor circuits and architectures
- Ultra low power and harsh environment VLSI systems
- High Security Digital Systems
- Research Opportunities:
  - Radiation hardened, high performance, low power, microprocessor design
  - Security circuits (smart cards, ultra-secure ICs)
  - Low power cache, MMU design
  - Multicore microprocessor circuits and programming

Students hired by: AMD, Intel, Qualcomm, Microchip, FreeScale, MRDC, TI
Self-Learning Adaptive Circuits & Systems

Real-time Sparse Coding
- Custom ASIC chip achieving **real-time** data collection, learning, and recognition
- Brain-inspired machine learning algorithms to manage device fluctuations, and to realize efficient on-line feature extraction (training)
- Hardware demonstration with **>5000X speedup** in information processing compared to CPU/GPU

On-chip Voltage Regulation
- On-chip voltage conversion / regulation is necessary to support multiple on-chip voltages with fast response
- On-chip voltage regulators based on switched-capacitor converters, low dropout regulators
- Achieve high-efficiency, high current density and minimal droop/noise
ENERGY EFFICIENT ARCHITECTURE – PRODUCTIVE VLSI DESIGN

Benchmark Applications

Custom Compiler

Simulator

Architecture Generation

Hardware Optimizer

Hardware Generator

Quality of Result

Physical Design

Design Constraints
BioEngineering – Research

- Life Sciences
- Cellular
- Molecular
- Physiological
- Engineering
- Circuits
- Control Systems
- MEMS
Sensor and Sensor Systems

Micro system on soft substrate (Parylene, PDMS, Polyimide):
- Flexible, stretchable and networked
- 3D surface manufacture
- Biomedical and geology applications

Fluidic parameters measurement:
- Sensors: thermal anemometer, electrodes
- Functions: shear stress, temperature, conductivity, dissolved oxygen.....
- Networked sensor meshes
- Geochemistry and astrobiology applications

Miniature seismometers for harsh environments
- Based on Molecular Electric Transducer with liquid electrolyte, using microfabrication improve size and performance.
- Applications: space exploration, gas or oil detection
UNDERGRADUATE RESEARCH ENGAGEMENT

- Fulton Undergraduate Research Initiative (FURI)
  http://more.engineering.asu.edu/furi/program-requirements/
- NASA Undergraduate Space Grants
  http://nasa.asu.edu/
- Senior Design Projects
  http://ece.ee.engineering.asu.edu/programs/undergraduate/
**WHERE DO WE FIND JOBS? (1/2)**

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>RANKING</th>
<th>EMPLOYEES</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel Corp.</td>
<td>7</td>
<td>11,000</td>
<td>Semiconductors</td>
</tr>
<tr>
<td>Raytheon Co.</td>
<td>14</td>
<td>9600</td>
<td>Missiles</td>
</tr>
<tr>
<td>Honeywell International Inc.</td>
<td>15</td>
<td>9500</td>
<td>Aerospace</td>
</tr>
<tr>
<td>General Dynamics Corp.</td>
<td>32</td>
<td>4500</td>
<td>Defense, communications</td>
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<tr>
<td>Boeing</td>
<td>34</td>
<td>4300</td>
<td>Aircraft</td>
</tr>
<tr>
<td>IBM Corp.</td>
<td>85</td>
<td>1800</td>
<td>Technology services</td>
</tr>
<tr>
<td>Freescale Semiconductor Ltd.</td>
<td>87</td>
<td>1720</td>
<td>Semiconductors</td>
</tr>
<tr>
<td>Microchip Technology Inc.</td>
<td>87</td>
<td>1720</td>
<td>Semiconductors</td>
</tr>
<tr>
<td>Orbital Sciences Corp.</td>
<td>91</td>
<td>1650</td>
<td>Aerospace</td>
</tr>
</tbody>
</table>

*Arizona Republic 2015 – top [largest employer] 100 companies in AZ.*
WHERE DO WE FIND JOBS? (2/2)

Top 50 companies to work for:
[Fortune Magazine 2014]

- Google
- Intel
- Microsoft
- Qualcomm
- Burns & McDonnell
- National Instruments (no longer NI)
WHERE HAVE OUR UNDERGRADUATES GONE?

- Intel
- Qualcomm
- Broadcom
- Microchip
- FreeScale
- On Semiconductor
- MRDC
- AMD
- Texas Instruments
- RFMD/TriQuint now Qorvo
- Medtronic
- Google
- Apple
- Government Labs
- Startup Companies
WHAT ARE OUR UNDERGRADUATES DOING?

• Applications Engineer – In field technical customer support of electronics
• Verification and Test Engineer – performance testing on electronics, volume production testing, testing of product prototypes
• Electronic Design Engineer – integrated circuit (IC) designers, board-level circuits designers, circuit/board layout
• Marketing – marketing, company representation, customer support
• Talent (Employee) Recruiting – college recruiting, recruit employees at career fairs and through outreach
• Other – graduate school, teaching, community service, HR…
QUESTIONS???