EE105 – Spring 2008
Microelectronic Devices and Circuits

http://www-inst.eecs.berkeley.edu/~ee105

Prof. Ming C. Wu

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261M Cory Hall

Teaching Assistants

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- Office Hours will be announced on the web

What is this class all about?

- Basic semiconductor device physics and analog integrated circuits.

- What will you learn?

  - Electrical behavior and applications of transistors

  - Analog integrated circuit analysis and design

Schedule

- Lectures:
  - TuTh 3:40-5:00 PM (102 Moffitt)

- Discussion Sections (beginning Monday 1/28):
  - Section 102 (293 Cory):   Mon. 4-5PM
  - Section 103 (2305 Tolman):   Wed. 10-11AM
  - Section 104 (140 Barrows):   Thu. 9-10AM

Lab Schedule

- **Laboratory Sections (beginning Monday 1/28):**
  - Section 10 (353 Cory):   Monday 9AM-12PM;
  - Section 11 (353 Cory):   Tuesday 10AM-1PM;
  - Section 12 (353 Cory):   Wednesday 2-5PM;
  - Section 13 (353 Cory):   Thursday 5-8PM;
- **Students must sign up for one lab section outside 353 Cory by 5PM Friday 1/25**, and regularly attend this lab section.
- Switching lab needs consent from both TAs
- All of the lab assignments (and tutorials) are posted online at
  http://inst.eecs.berkeley.edu/~ee105/sp08/#labs
- Each pre-lab assignment is due at the beginning of the corresponding lab session. Post-lab assignments are due at the beginning of the following lab section.

Relation to Other Courses

- **Prerequisite:**
  - EECS40: KVL and KCL, Thevenin and Norton equivalent circuits, impedance, frequency response (Bode plots), semiconductor basics, simple pn-junction diode and MOSFET theory and circuit applications, analog vs. digital signals.

- **Relation to other courses:**
  - EE105 is a prerequisite for EE113 (Power Electronics) and EE140 (Linear Integrated Circuits).
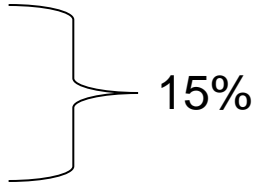 - It is also helpful (but not required) for EE141 (Introduction to Digital Integrated Circuits).
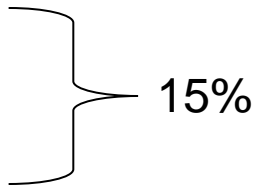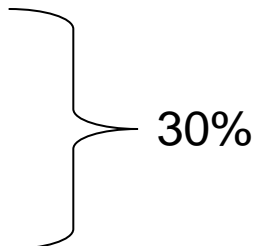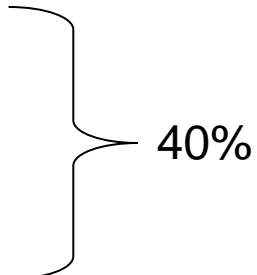
Class Materials

- Textbook:

  - *Fundamentals of Microelectronics*
    by Behzad Razavi, Wiley Press, January 2008

- Lecture Notes will be posted on the class website, but it is important that you read the corresponding sections in the textbook

- Lectures will be recorded and webcasted, however, this is not intended to replace attendance

Homework

- Weekly assignments will be posted online on Tuesdays

- Due the following Tuesday at 5:10 PM @EE105 Drop box in Undergraduate Lounge, Cory Hall).

- Late homework will not be accepted.

- Students are encouraged to discuss homework problems. However, <u>the work which you submit for grading must be your own</u>.

Grading

- **Homework** (posted online)
  - *due Tu (5:10PM at Drop Box in Undergrad Lounge)*
  - *late homeworks not accepted*

  — 15%

- **Laboratory assignments**
  - *Prelab due at beginning of lab session*
  - *Report due at the beginning of the following lab*

  — 15%

- **2 midterm exams**
  - *80 minutes each*
  - *closed book (3 pages of notes allowed)*

  — 30%

- **Final exam**
  - *Th 5/22 from 12:30-3:30PM*
  - *closed book (7 pages of notes allowed)*
  - *bring calculator*

  — 40%

Miscellany

- Special accommodations:
  - Students may request accommodation of religious creed, disabilities, and other special circumstances. Please make an appointment to discuss your request, in advance.

- Academic (dis)honesty
  - Departmental policy will be strictly followed
  - Collaboration (not cheating!) is encouraged

- Classroom etiquette:
  - Arrive in class on time!
  - Bring your own copy of the lecture notes.
  - Turn off cell phones, pagers, MP3 players, etc.
  - No distracting conversations

Some Important Announcements

- Please don't bring food/drinks to 353 Cory

- Lab experiments will be done in pairs. Each person should turn in his/her individual reports.

- Homework should be done individually.

- Cheating on an exam will result in an automatic F course grade.

Getting Started

- Assignment 1:
  - To be posted later today
  - Due 1/29 (Tuesday) at 5 PM
- NO discussion sessions, labs, or office hours this week.

Course Overview

(refer to detailed syllabus)

Introduction

The Integrated Circuit (IC)

- **An IC consists of interconnected electronic components in a single piece ("chip") of semiconductor material.**

  - **In 1958, Jack S. Kilby (*Texas Instruments*) showed that it was possible to fabricate a simple IC in germanium.**

  - **In 1959, Robert Noyce (*Fairchild Semiconductor*) demonstrated an IC made in silicon using SiO_2 as the insulator and Al for the metallic interconnects.**
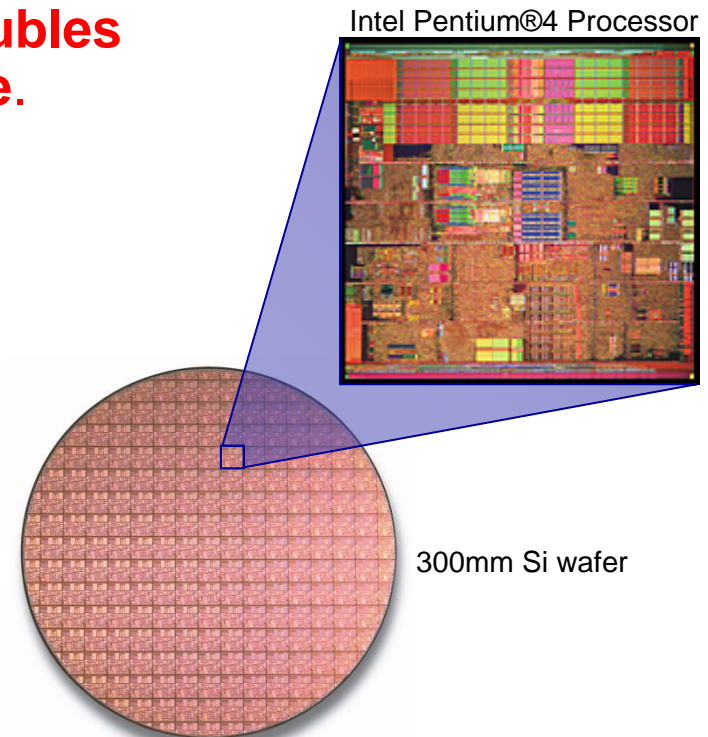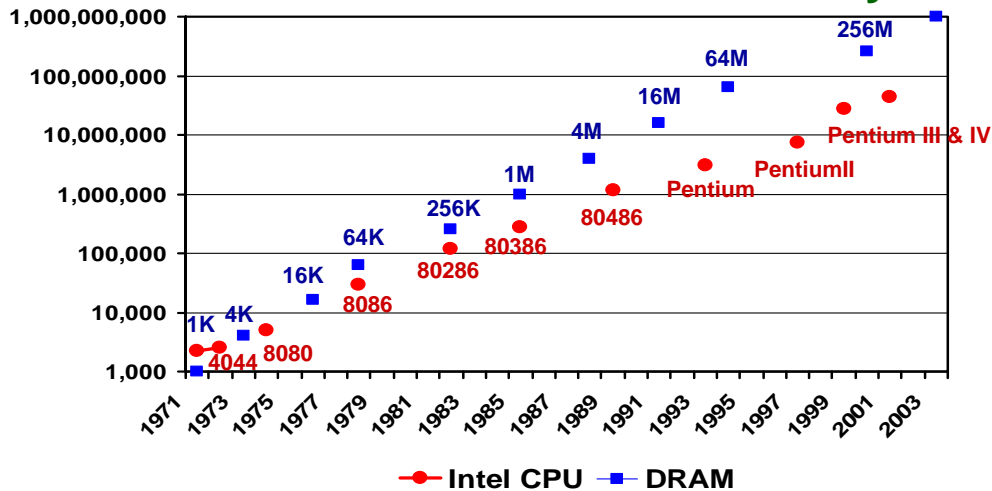

Kilby's first integrated circuit in germanium.
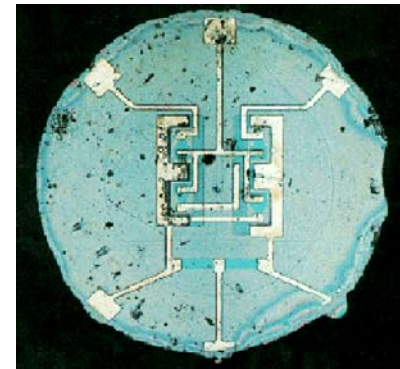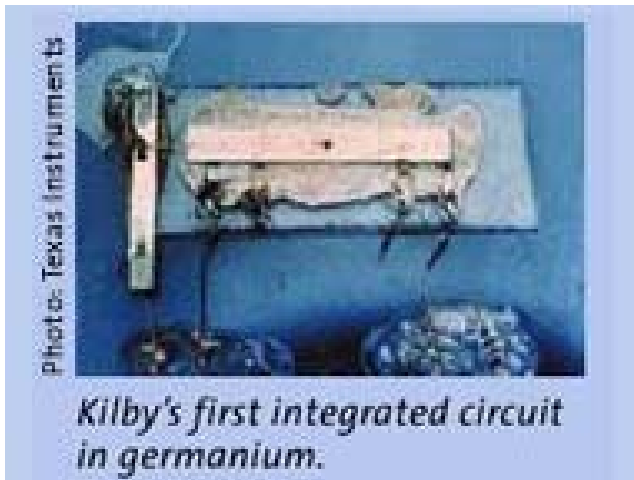
**The first planar IC
(actual size: 0.06 in. diameter)**
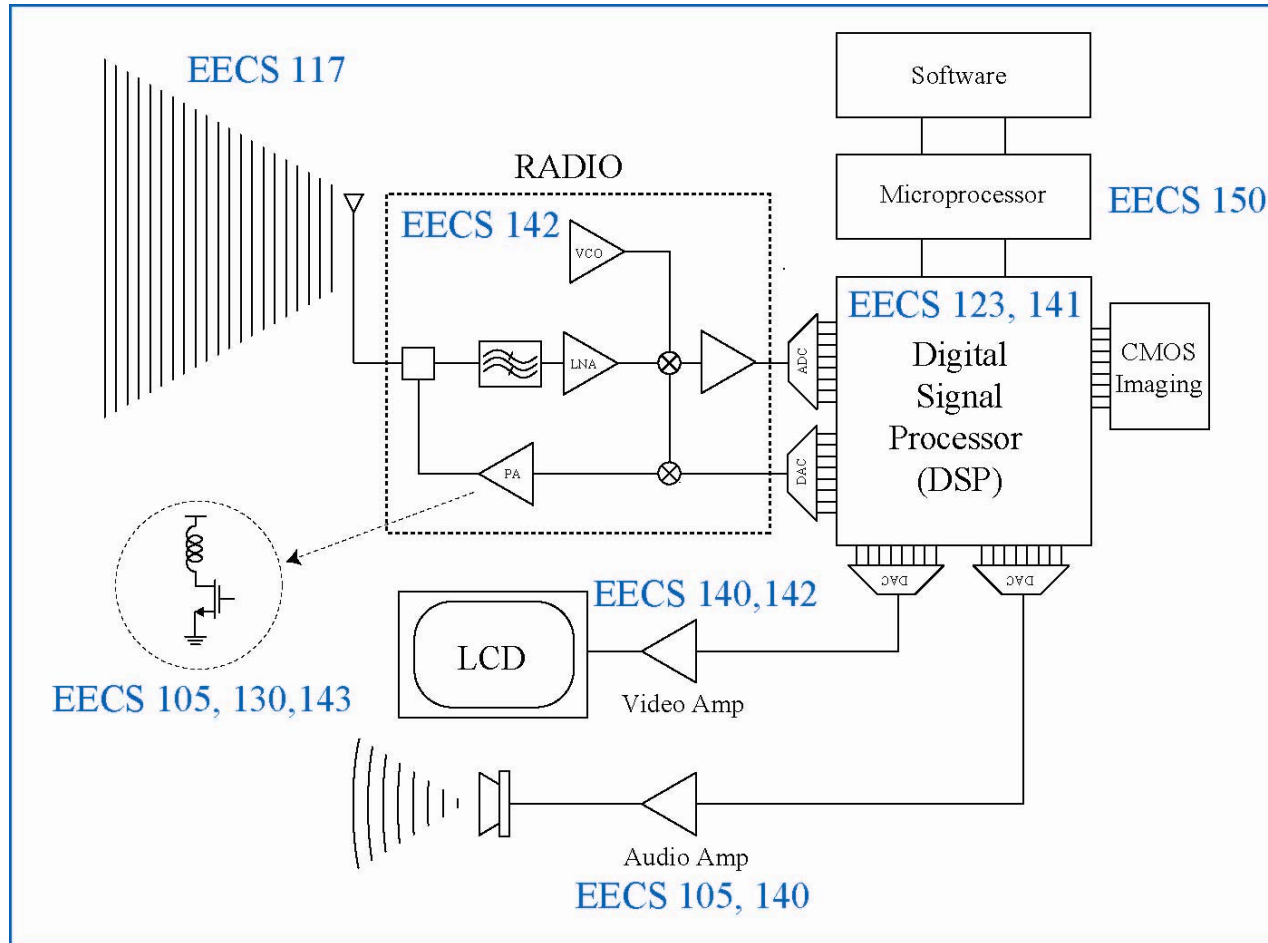
From a Few, to Billions

- **By connecting a large number of components, each performing simple operations, an IC that performs very complex tasks can be built.**

- **The degree of integration has increased at an exponential pace over the past ~40 years.**

  » **The number of devices on a chip doubles every ~18 months, for the same price.**

  "Moore's Law" still holds today.

Intel Pentium®4 Processor

300mm Si wafer

Legend: **Intel CPU** (red) **DRAM** (blue)

EECS 105 in the Grand Scheme

- Example electronic system: cell phone

EECS 117

RADIO

EECS 142   VCO

EECS 105, 130,143

ADC

DAC

PA

LNA

Software

Microprocessor   EECS 150

EECS 123, 141
Digital
Signal
Processor
(DSP)

CMOS
Imaging

DAC   DAC

EECS 140,142

LCD

Video Amp

Audio Amp
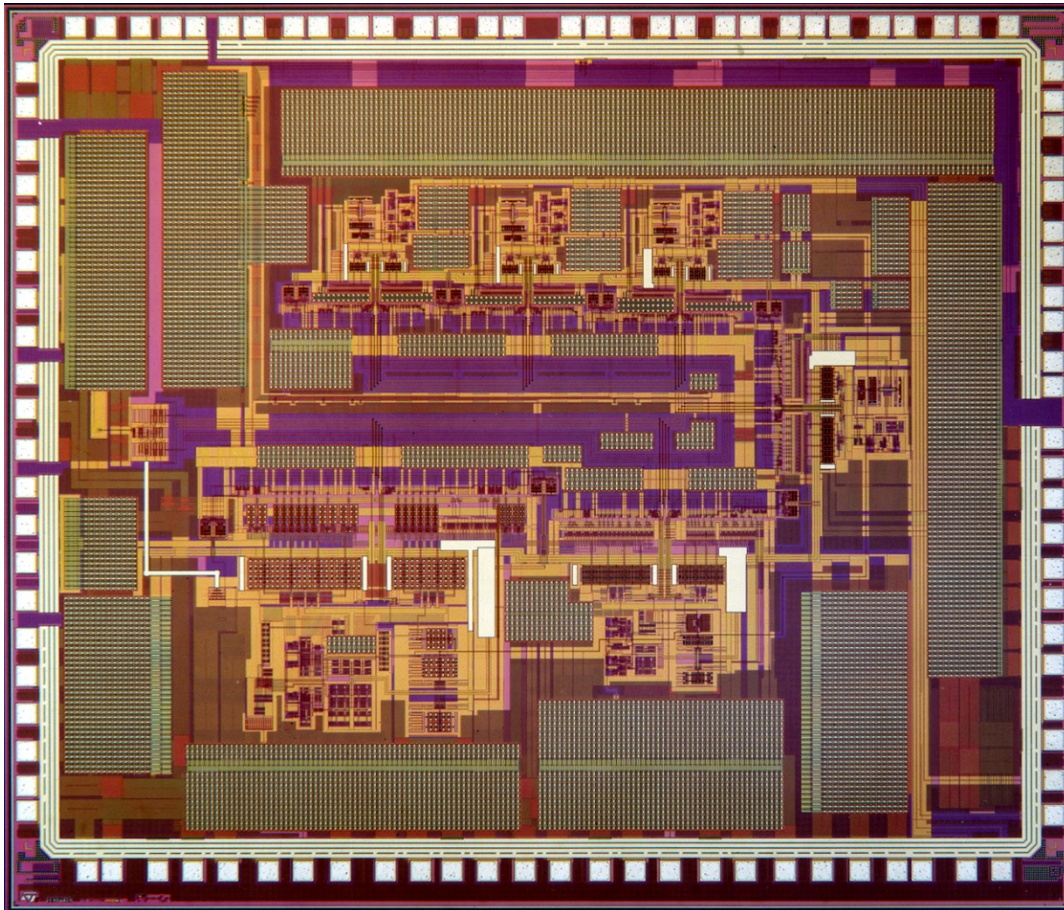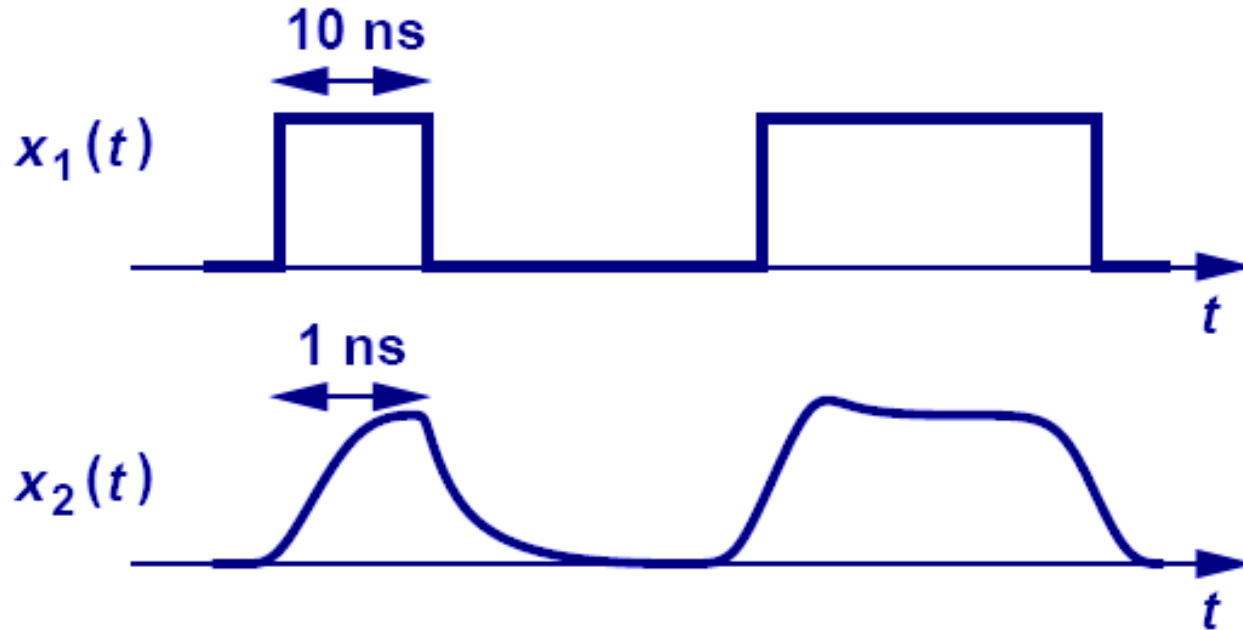
EECS 105, 140

ENTIRE SYSTEM: EECS 120, 126, 121

EECS 105: Emphasis on Analog IC's

- Example: 14-bit analog-to-digital converter
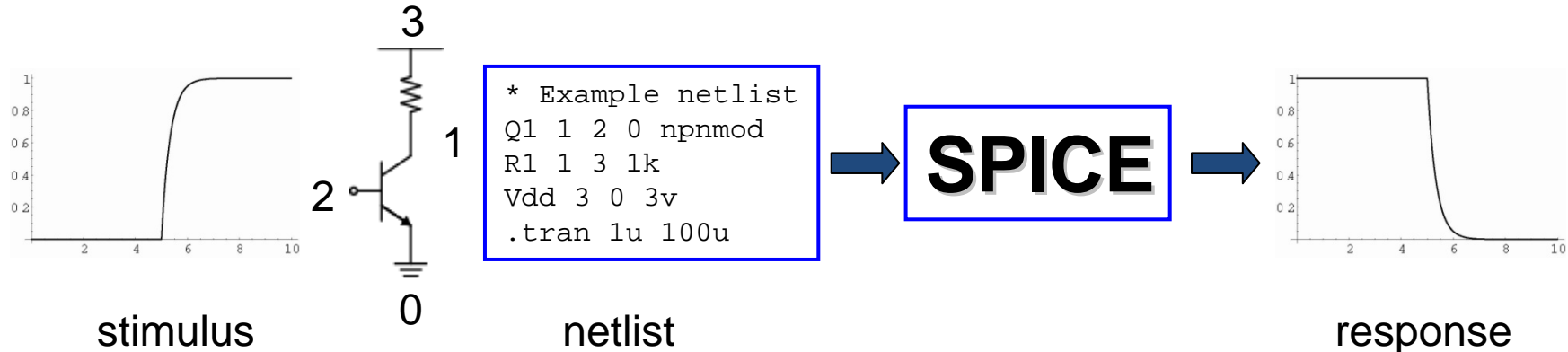 - Y. Chiu, *IEEE Int'l Solid-State Circuits Conference*, 2004.

Digital or Analog Signal?

- $X_1(t)$ is operating at 100Mb/s and $X_2(t)$ is operating at 1Gb/s.
- A digital signal operating at very high frequency is very "analog".

Circuit Simulation using SPICE

- ## Read tutorial posted on EE105 lab website!


```
* Example netlist
Q1 1 2 0 npnmod
R1 1 3 1k
Vdd 3 0 3v
.tran 1u 100u
```

SPICE

stimulus   netlist   response

- SPICE = Simulation Program with IC Emphasis
- Invented at Berkeley (released in 1972)
- .DC: Find the DC operating point of a circuit
- .TRAN: Solve the *tran*sient response of a circuit (solve a system of generally non-linear ordinary differential equations via adaptive time-step solver)
- .AC: Find steady-state response of circuit to a sinusoidal excitation