ECE-606: Spring 2013

Course Introduction

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PURDUE UNIVERSITY

course objectives

*To **introduce** students to the fundamentals of semiconductors and semiconductor devices.*

electron devices

vacuum tube

Edison effect, 1880
J.J. Thompson, 1897
diode (Fleming, 1904)
triode (De Forest, 1905)

transistor

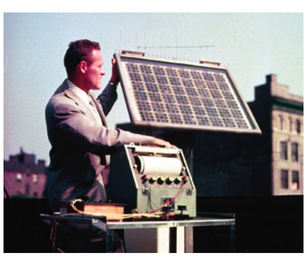
Bardeen, Brattain,
Shockley, 1947

integrated circuit

Kilby /Noyce, 1958

electron devices

modern solar cell

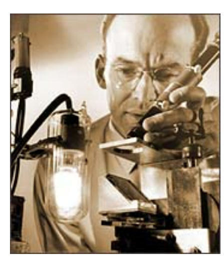


Chapin, Pearson, Fuller,
1954

LED

Holonyak, 1962

semiconductor
laser



Hall, 1962

Purdue's semiconductor history

"Karl Lark-Horovitz is best known for turning the physics department of Purdue University, then a backwater school, into a research powerhouse. His personal research was in germanium and solid state science -- and if anyone had had a chance of inventing the transistor before Bell, it was Lark-Horovitz. As it was, the Purdue physics lab was probably only six to twelve months behind."

http://www.pbs.org/transistor/album1/addlbios/lark.html

1941: WWII: Semiconductor diode rectifiers
http://www.computerhistory.org

electronics in the 21st Century

CMOS transistors for logic
III-V transistors for RF
A/D and D/A convertors
Digital Signal processor
Microprocessor
ROM and FLASH memory

CMOS imager
Gyroscope
MEMS devices
Magnetometer
Microphone, speaker
LCD display and touch screen

www.apple.com

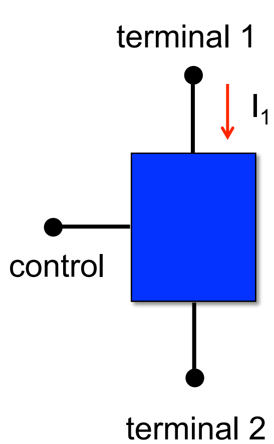
transistors

"The **transistor** was probably the most important invention of the 20th Century, and the story behind the invention is one of clashing egos and top secret research."

- Ira Flatow, Transistorized!

http://www.pbs.org/transistor/

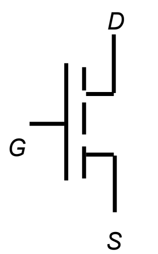
transistors

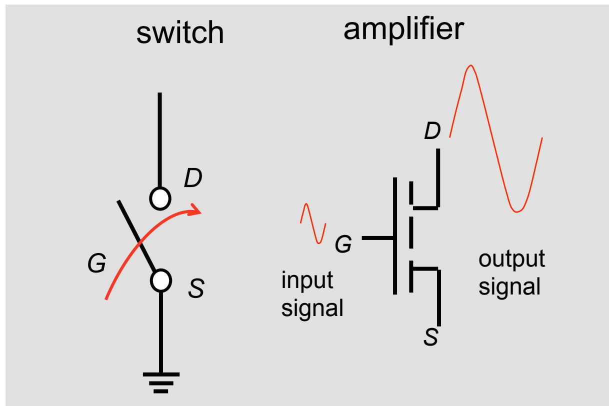


point contact transistor
bipolar transistor
MOSFET
JFET
SOI MOSFET
SB FET
FinFET
MODFET (HEMT)
heterojunction bipolar transistor
velocity modulation transistor
BTBT FET
SpinFET
…

uses for transistors

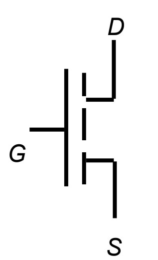
symbol

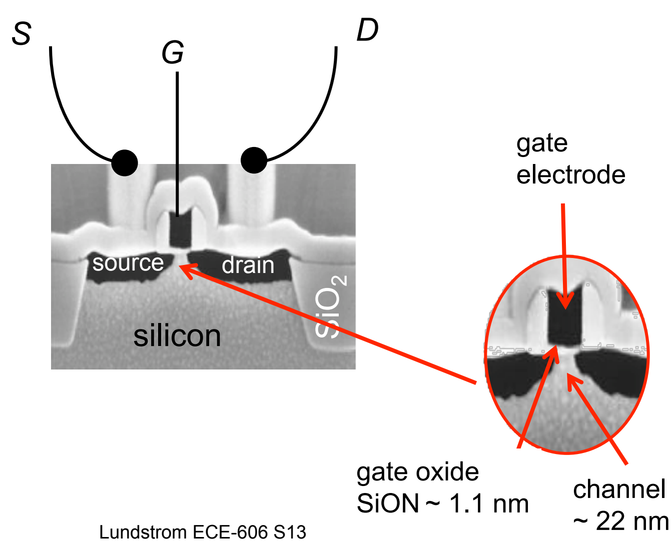




real transistors

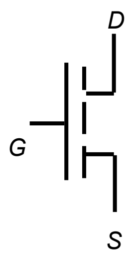
symbol

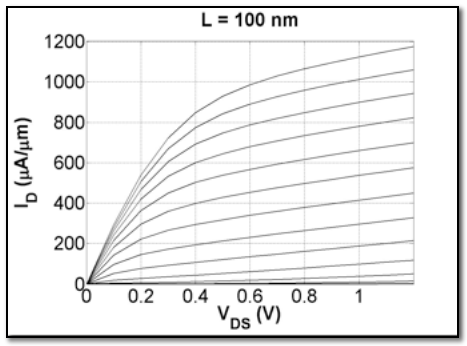




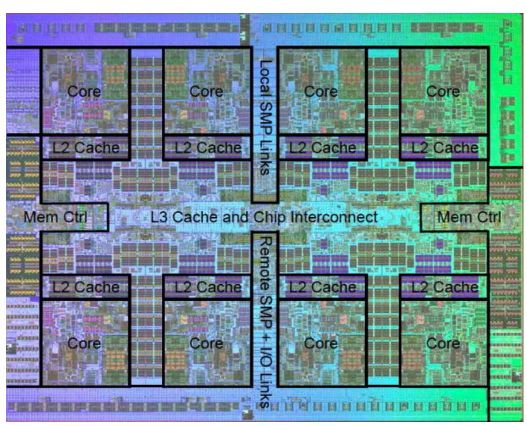
transistor IV

symbol





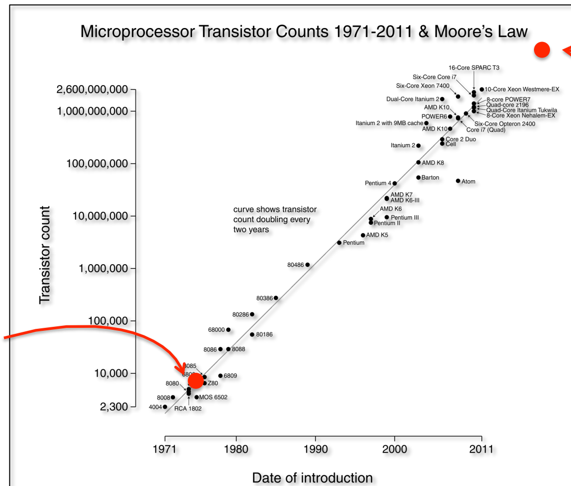
integrated circuits



IBM Power7 (45nm, 1.2B transistors)

http://arstechnica.com/business/news/2010/02/two-billion-transistor-beasts-power7-and-niagara-3.ars

Moore's Law



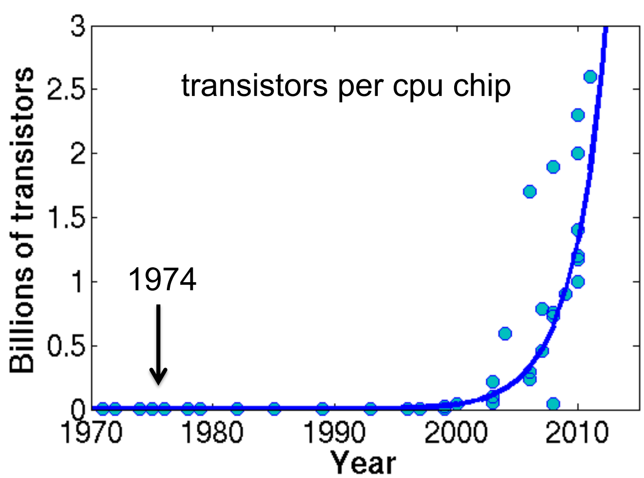
$L = 5000$ nm

Micro-electronics

$L = 5$ nm

Nano-electronics

exponential growth

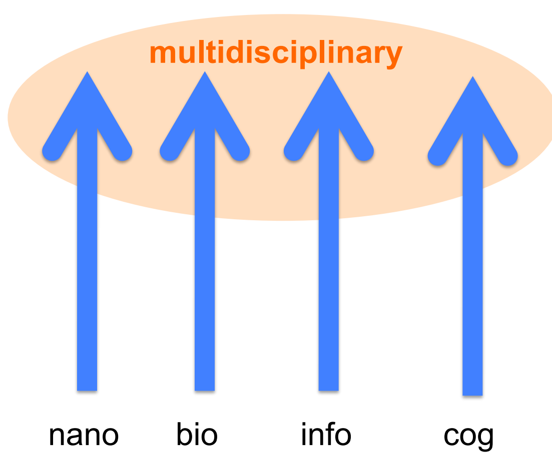


"The most important moment since man emerged as a life form."

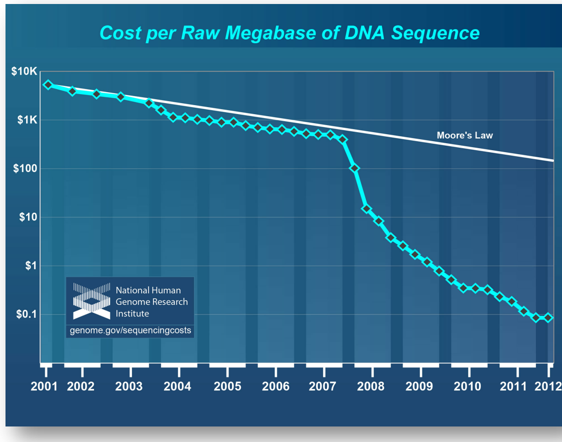
Isaac Asimov

(about the "planar process" used to manufacture ICs (invented by Jean Hoerni, Fairchild Semiconductor, 1959).

"converging technologies"

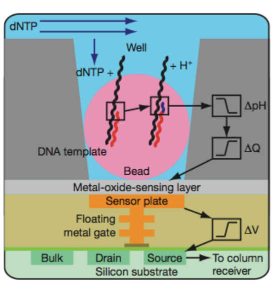


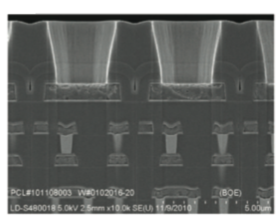
example: gene sequencing

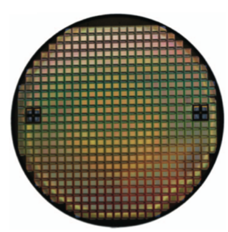


http://www.genome.gov/sequencingcosts/

Electronics beyond Moore's Law



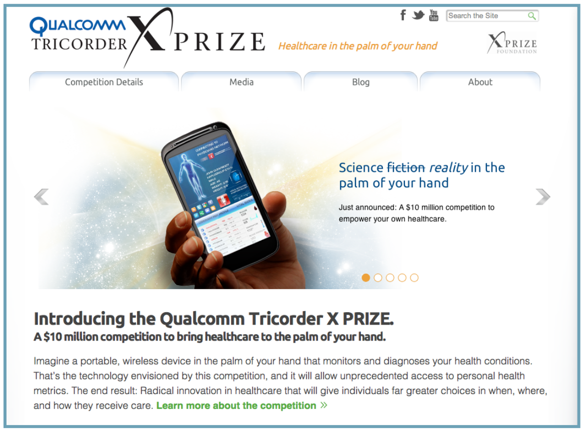




Ion Torrent (*Nature*, **475**, 349, 21 July, 2011)

NBIC convergence

Electronics and healthcare



Electronics and:

-Energy

-Environment

-Cognition

-Security

-Personalized learning

-…

http://www.qualcommtricorderxprize.org

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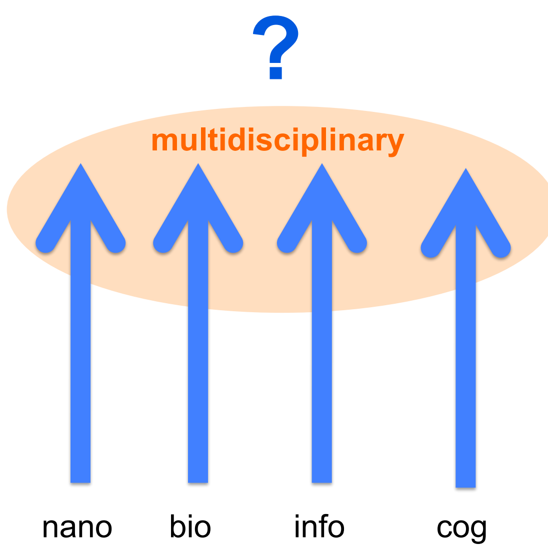
transdisciplinary R&D



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course outline

Part 1: Semiconductor Fundamentals:	7 weeks
Part 2: PN diodes, MS diodes, and LEDs	2 weeks
Part 3: Transistors	6 weeks

course texts

Advanced Semiconductor Fundamentals, 2nd Edition (ASF)
R.F. Pierret, Pearson Education, Inc., 2003.
ISBN-0-13-061792-X (paperback)

Semiconductor Device Fundamentals, 2nd Edition (SDF)
R.F. Pierret, Addison-Wesley Publishing Co, 1996.
ISBN-0-201-54393-1

course format: "flipped"

Week 1: Introduction / Geometry of Crystals

Reading Assignment: Applied Semiconductor Fundamentals, 2nd ed., R.F. Pierret, pp. 10-17

ECE 606 Lecture 1: Introduction
Quiz 1 Week1Quiz1.pdf (42.9 Kb)
ECE 606 Lecture 2: Geometry of Periodic Crystals
Quiz 2 Week1Quiz2.pdf (40.61 Kb)

Week 1 Homework Assignment Week1HW.pdf (132.86 Kb)
Week 1 Homework Solution

Week 1: Answers to Quizzes

Week 1: References and Supplementary Information

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http://nanohub.org/groups/ece606lundstrom

grading

Lecture quizzes and questions:	**25%**
Exams (5 at 15% each)	**75%**

Quiz score = x/total times 25%, where x is the number of quizzes you turned in and passed and total is the total number of lectures in the course.

Exam score = average of the percentage scores of the 5/6 best exams scores including any retake.

Approximate curve:

A:	91 – 100%
B:	81 – 90%
C:	71 – 80%
D:	61 – 70%
F:	60% or less

Steven Chu:

“Learning science and thinking about science or reading a paper in science is not about learning what a person did. You have to do that, but **to really absorb it, you have to turn it around** and cast it in a form as if you invented it yourself. You have to look and be able to see things that other people looked at and didn't see before.

How do you do that? There are two ways. Either you make a new instrument, and it gives you better eyes, … Or you **try to internalize it in such a way that it really becomes intuitive.**

questions