ELEC 424
Solid State Devices

Course Introduction

Outline

- Important Stuff
- Course Introduction
  - Why Solid State Devices Matter
  - What are Solid State Devices
  - What is Solid State
  - How we got here
  - Moore's Law
- Homework

Important Stuff

- Text: Solid State Electronic Devices, Streetman and Banerjee, 6th Edition
- Syllabus – handout and on website

http://ece.citadel.edu/peeples/

- Class schedule – syllabus
- Research Assignment – handout and website

Why are Solid State Devices Important?

- Simple answer – they fuel the gross national product, just as oil did for most of the 20th century.
- More thorough answer – all of our modern electronic devices are a collection of solid state devices
  - Computer
  - Instruments
  - Cars and Airplanes
  - Homes and Bathrooms

What is Solid State?

- Simple answer – the difference between ENIAC and Pentium
- More thorough answer – the electronic behavior of solids as in the following:
  - Bulk materials
  - Diodes
  - Transistors
    - Bipolar
    - Field Effect
  - Other
    - Integrated circuits
    - Photovoltaic devices
    - Special sensors

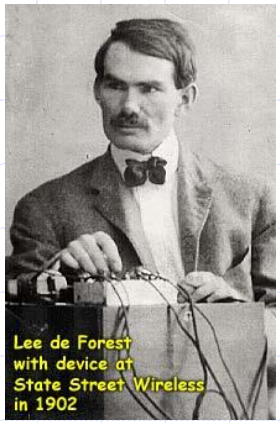
The Early Early Years

- 1874, Ferdinand Braun discovered rectification, that electricity will travel in one direction in some crystals.
- 1895, Guglielmo Marconi introduced what would become wireless communications, using crystals to separate carrier from information

John Ambrose Fleming

- 1904, Invented the first vacuum tube diode, the thermionic, or “Fleming” valve,.
- Studied the “Edison Effect” and applied his tubes to create rectifying circuits.
- Perhaps he invented “Electrical Engineering”, as he was the first department head of England’s first Department of Electrical Technology, later renamed Electrical Engineering.

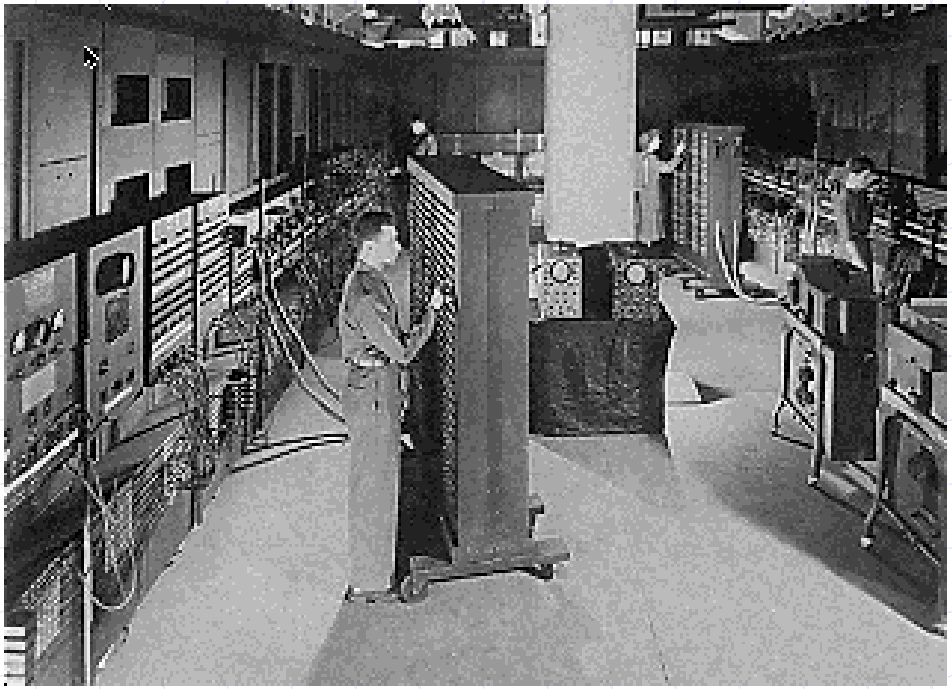
Lee deForest



- 1906, Added the important third grid to Fleming's Valve to create the triode and the ability to amplify electronic signals. The triode is the transistors closest ancestor.
- Vacuum tubes remain an important microwave technology.

ENIAC

Electronic
Numerical
Integrator
And
Computer

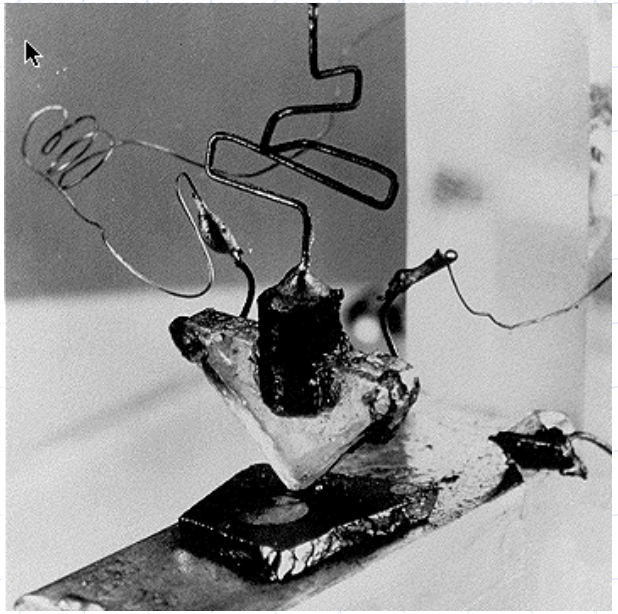


- Designed by the US Army and University of Pennsylvania to solve complex ballistics problems.
- Professor Brainard, Dr. Eckert, and Dr. Mauchly designed a 19,000 vacuum tube device that required air conditioning.
- Eckert and Mauchly later patented the idea of an electronic computer

Source: The Story of ENIAC, http://ei.cs.vt.edu/~history/ENIAC.Richey.HTML

Transistors

- Drs. Bratain and Bardeen invented the transistor at Bell Labs in 1947 .
- Dr. Schokley developed critical junction theory and the first junction transitor in 1948.
- All received the Nobel Prize for this November 1947 through February 1948 effort.

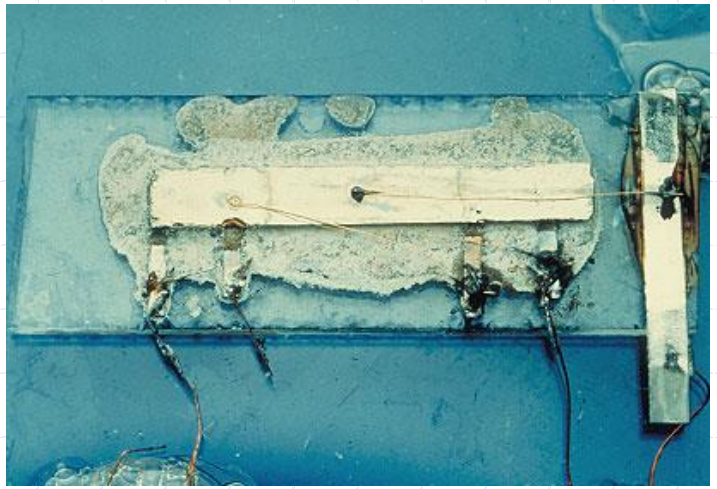


Source: The Miracle Month, http://www.pbs.org/transistor/background1/events/miraclemo.html

Integrated Circuits

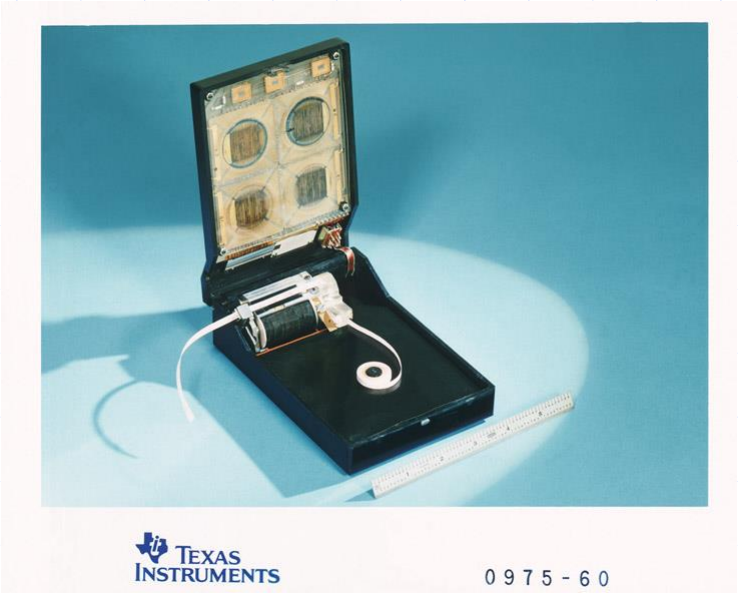
- Mr. Jack Kilby invented the Integrated Circuit (IC) at Texas Instruments in 1959.

Jack was a new employee with no vacation during the annual 2 week shutdown, so he stayed at work and changed the world.



Source: Creating The First Integrated Circuit, http://www.ti.com/corp/docs/company/history/tihistory_subpage1.shtml

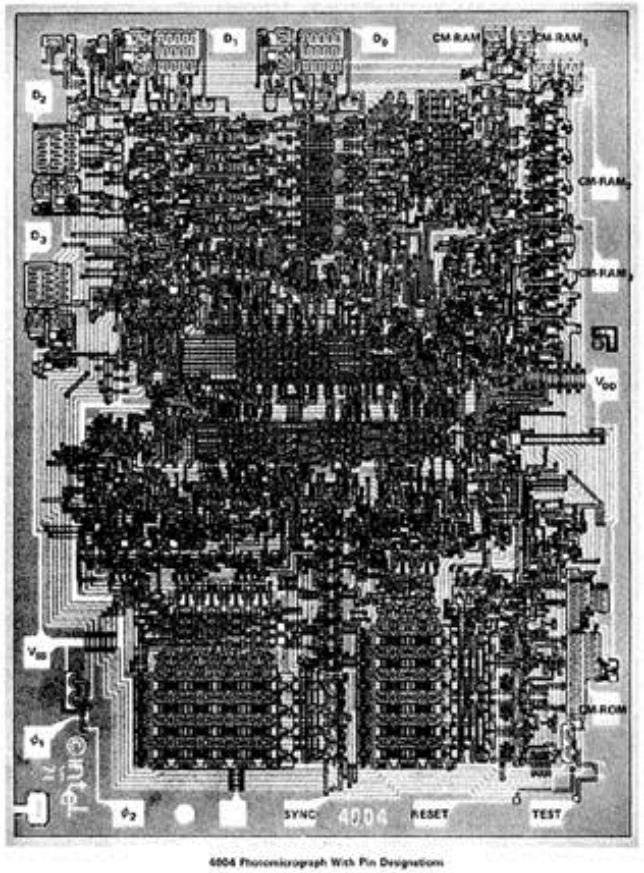
The First Handheld Calculator



- The electronic hand-held calculator was invented at Texas Instruments in 1967 by Jack Kilby, Jerry Merryman, and James Van Tassel.
- 4-1/4 x 6-1/8 x 1-3/4-inches, the first mini-calculator to have the computational power of larger machines. An integrated circuit array that contained all the electronics for performing addition, subtraction, multiplication, and division.
- Since its invention predated any small display technology, it used a paper tape as an output device.

Microprocessors

- Drs. Moore, Noyce and Grove founded Intel and produced the first microprocessor in 1971, the 4004.



4004 Photomicrograph With Pin Designations

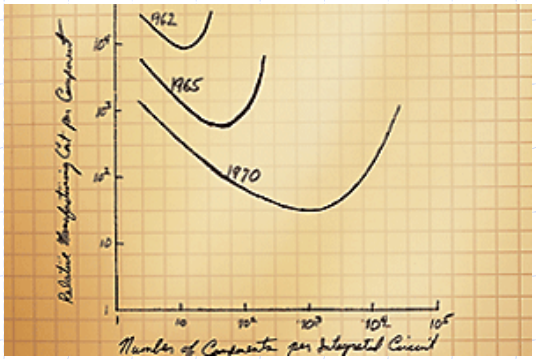
Source: Intel's First Microprocessor, the Intel® 4004, http://www.intel.com/museum/archives/4004.htm

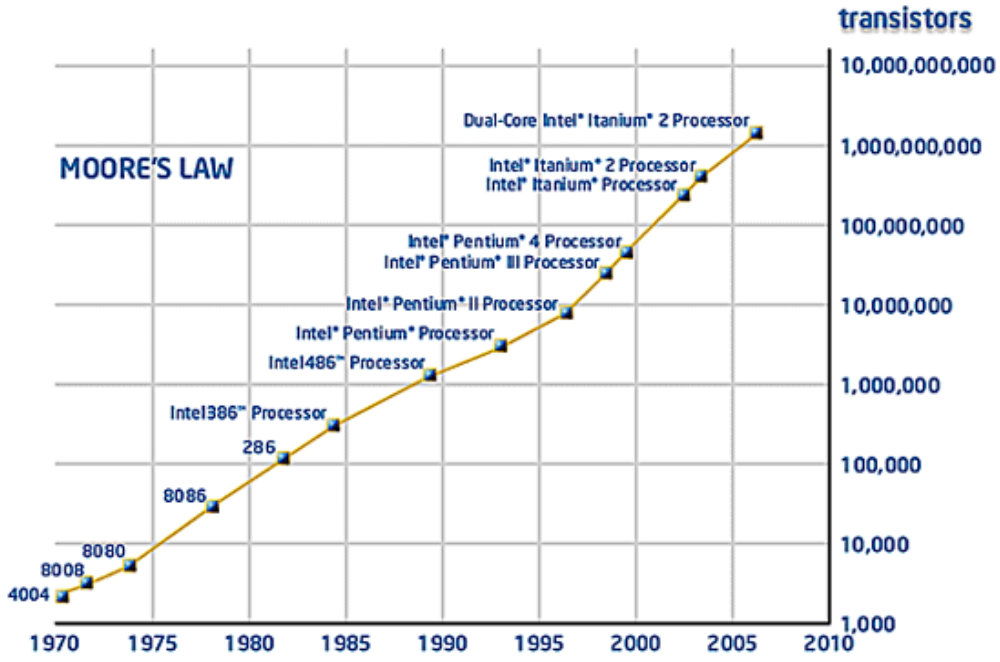
Moore's Law

- Gordon Moore noted that the number of components per unit chip area doubles every 18 – 24 months and ..
- Reducing feature size enables a matching increase in complexity, and often performance.

Class	# of devices
SSI (Small Scale IC)	~ 1 – 100
MSI (Medium Scale IC)	~ 100 - 1000
LSI (Large Scale IC)	~ 10^3 – 10^5
VLSI (Very Large Scale IC)	~ 10^5 – 10^6
ULSI (Ultra Large Scale IC)	~ 10^6 – 10^9
GSI (Giga Scale IC)	~ 10^9 – $10^?$
RLSI (Ridiculously Large Scale IC)	> GSI

Moore's Law





"..(T)he first microprocessor only had 22 hundred transistors. We are looking at something a million times that complex in the next generations—a billion transistors. What that gives us in the way of flexibility to design products is phenomenal." —Gordon E. Moore

Why Study the Physics?

- Simple answer – this is an engineering course
- More thorough answer – so you can not only use the tool, but design a better one
  - So you can design SS devices
  - So you can design circuits using SS devices
  - So you can predict what will and will not work
  - So you can keep pace with the technology

What Will I Learn?

- How solid state devices act
- Why solid state devices act the way they do
- What solid state devices can and cannot do

Homework Assignment

Answer the following from data within the 2013 edition of the "International Technology Roadmap for Semiconductors". The most recent (2013) and back years of the reports can be found at http://www.itrs.net/reports.html.

From the Executive Summary –

1. How many key contributors were in the "metrology" working group? How about in the "test and test equipment" group?
2. Just by glance, which group has the most key contributors?
3. Roughly, how many persons contributed to the roadmap in total?

From the entire document -

1. Click around the roadmap, be awed by its depth and staggered by its detail. Then find some obscure but interesting fact to share with the class in a couple of paragraphs (no more than one page) of writing. Do not simply cut and paste, but put what interests you in your own words.

Due Wednesday, May 13, 2015