Information

See course outline

Collect an email address list, list your English names if you have, ->TA mrhao@sjtu.....

Contact me by email h.c.liu@sjtu.edu.cn (no calls please) and come to see me during office hours (not other times please)

Qs for you:

- English course/lecture before?
- When can you make up classes?
- Office hours ok?
- Prefer early or late final exam?

Intro: Condensed Matters

- Solid
- Soft condensed matter

Intro: Solids

- Metals
- **Semiconductors**
- Insulators
- Superconductors
- …

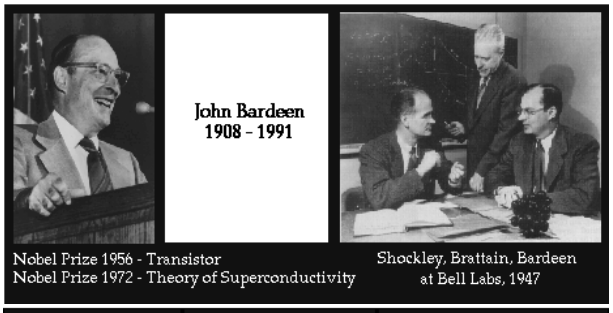
Intro: Semiconductors

- Transistors, IC (integrated circuit), PC (personal computer), Mobile phones, Digital camera, & ICT (information & communication technology)
- Processing: PC
- Capture: CCD (charge coupled device)
- Communication: wired (including fiber) and wireless, microwave and optoelectronic devices
- Energy: solar cells, LED (light-emitting diode) lighting / solid-state lighting

History

- **Vacuum tube -> transistor -> IC**
- **Vacuum tube computer – ENIAC (Electronic Numerical Integrator And Computer) 1945, 100kHz clock, 17,000 tubes, occupies a large room!**

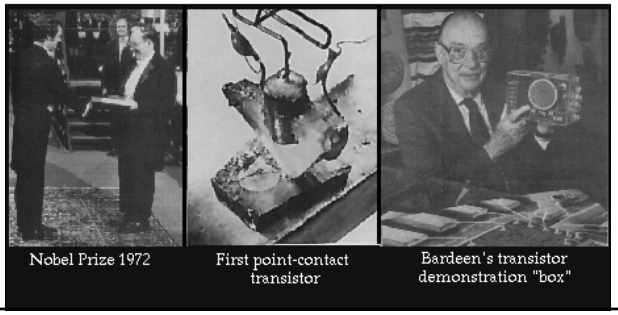
Transistor – 1947 invented



John Bardeen
1908 – 1991

Nobel Prize 1956 - Transistor
Nobel Prize 1972 - Theory of Superconductivity

Shockley, Brattain, Bardeen at Bell Labs, 1947



Nobel Prize 1972

First point-contact transistor

Bardeen's transistor demonstration "box"

Nobelprize.org

The Nobel Prize in Physics 2000

"for basic work on information and communication technology"

"for developing semiconductor heterostructures used in high-speed- and opto-electronics"

"for his part in the invention of the integrated circuit"

Zhores I. Alferov
1/4 of the prize
Russia
A.F. Ioffe Physico-Technical Institute
St. Petersburg, Russia
b. 1930

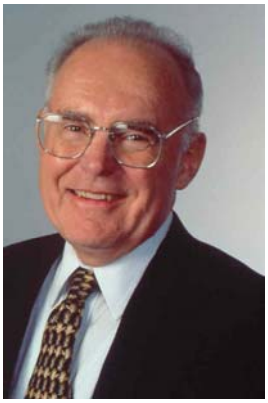
Herbert Kroemer
1/4 of the prize
Federal Republic of Germany
University of California
Santa Barbara, CA, USA
b. 1928

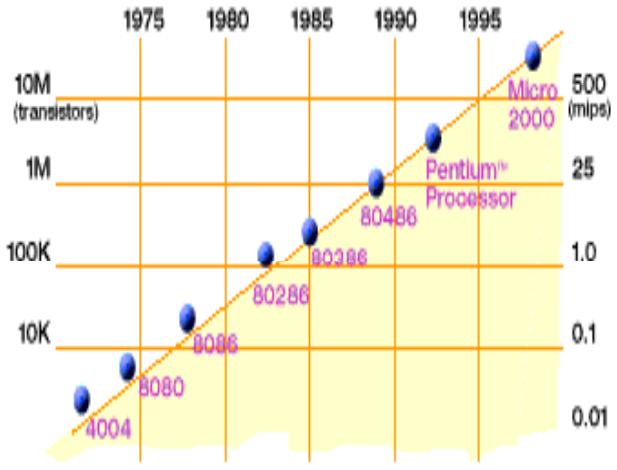
Jack S. Kilby
1/2 of the prize
USA
Texas Instruments
Dallas, TX, USA
b. 1923
d. 2005

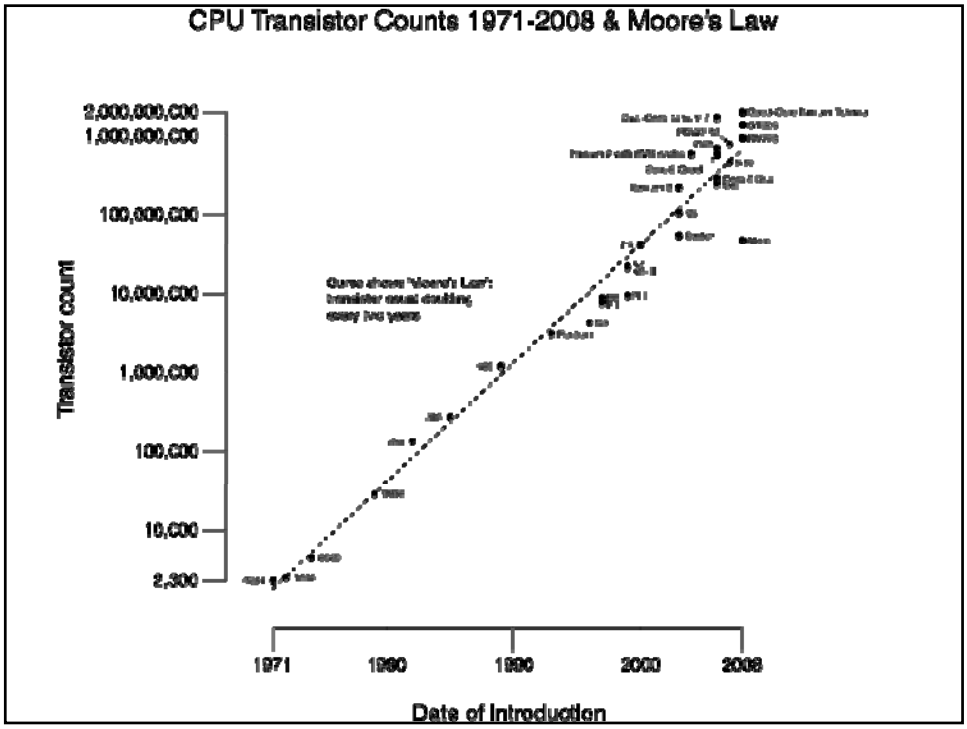
Jack S. Kilby is being rewarded for his part in the invention and development of the integrated circuit, the chip.

Through this invention microelectronics has grown to become the basis of all modern technology.

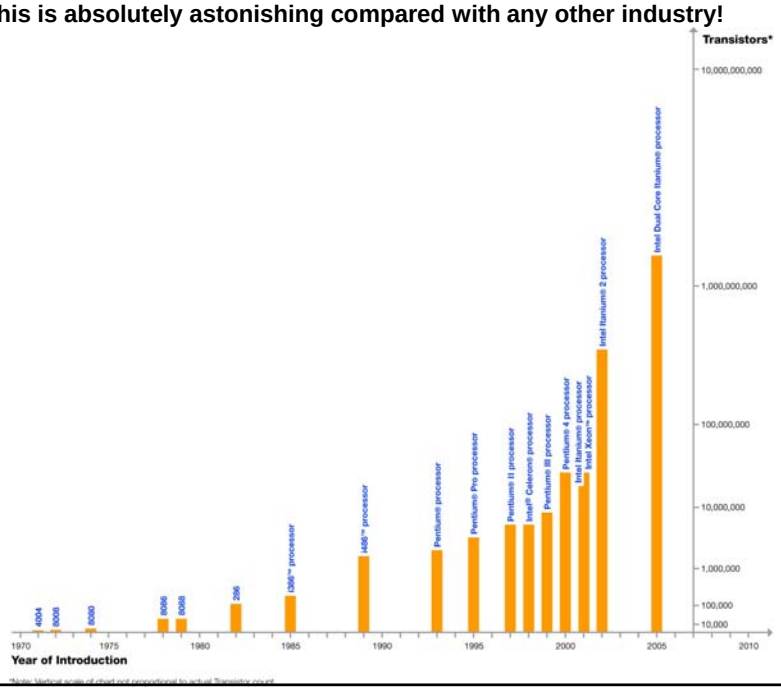
ICs rapidly advance following Moore's Law: Number of transistors, computing power, memory capacity doubles every two years







This is absolutely astonishing compared with any other industry!



Comparing to the airline industry:

In 1978, a commercial flight between New York and Paris cost around $900 and took seven hours. If the principles of Moore's Law had been applied to the airline industry the way they have to the semiconductor industry since 1978, that flight would now cost about a penny and take less than one second.

1947 – transistor invented

1955 – an all transistor computer introduced

1959 – first planer transistor, Kilby invented IC

Future – where is it going?

Predictions in the past:

"*I think there is a world market for five computers.*"

Thomas Watson, Chairman of IBM, 1943

" *There is no reason anyone would want a computer in their home.*"

Ken Olson, Chairman of DEC, 1977

Herbert Kroemer:

" *The principal applications of any sufficiently new and innovative technology always have been – and will continue to be – applications created by that technology.*"

Future Trends in Microelectronics, ed. Serge Luryi et al., Kluwer, Dordrecht, The Netherlands, 1996

Nobelprize.org

The Nobel Prize in Physics 2000

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"for his part in the invention of the integrated circuit"

Zhores I. Alferov	Herbert Kroemer	Jack S. Kilby
1/4 of the prize	1/4 of the prize	1/2 of the prize
Russia	Federal Republic of Germany	USA
A.F. Ioffe Physico-Technical Institute St. Petersburg, Russia	University of California Santa Barbara, CA, USA	Texas Instruments Dallas, TX, USA
b. 1920	b. 1928	b. 1923 d. 2005

Alferov and Kroemer have invented and developed fast opto- and microelectronic components based on layered semiconductor structures, termed semiconductor heterostructures.

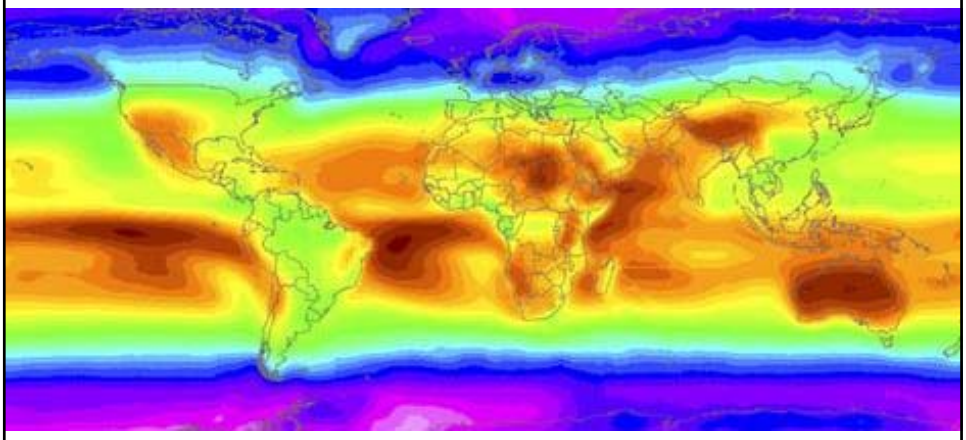
Fast transistors built using heterostructure technology are used in e.g. radio link satellites and the base stations of mobile telephones.

Laser diodes built with the same technology drive the flow of information in the Internet's fiber-optical cables. They are also found in CD players, bar-code readers and laser pointers.

CCD inventors share 2009 Nobel Prize in physics

Willard Boyle [left] and George Smith [right] in 1974

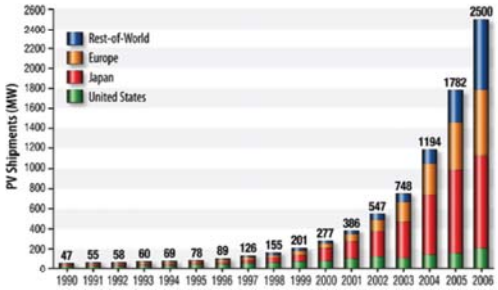
Solar cells



NASA's map of solar energy hitting earth's surface

Introduction: *Solar energy and its future*

Rapidly growing photovoltaic industry:

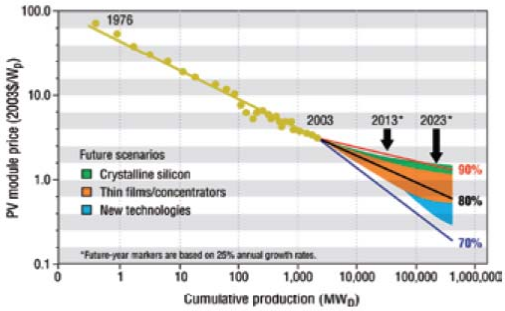


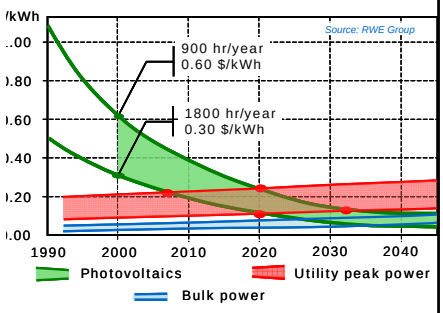
World photovoltaic module production (in megawatts), total consumer, and commercial per country (from *PV News*, Paul Maycock, Editor; February 2004). Most of this production is from crystalline or multi-crystalline Si solar cells at present.

However, the total solar electricity produced is still less than 1% of the total electricity production.

Courtesy: Ye Tao

Introduction: *Solar energy and its future*





Ginley et al. MRS BULLETIN • VOLUME 33 • APRIL 2008

Next 10 years: Si based ~$1-1.5/W
Target: $0.33/W, or $50/m^2,

The cost of solar electricity becomes competitive with peak-power grid energy over the next decade, and then further evolves to provide economical solar bulk power.

Courtesy: Ye Tao

Nobelprize.org

The Nobel Prize in Physics 1998

"for their discovery of a new form of quantum fluid with fractionally charged excitations"

Robert B. Laughlin

1/3 of the prize

USA

Stanford University
Stanford, CA, USA

b. 1950

Horst L. Störmer

1/3 of the prize

Federal Republic of Germany

Columbia University
New York, NY, USA

b. 1949

Daniel C. Tsui

1/3 of the prize

USA

Princeton University
Princeton, NJ, USA

b. 1939
(in Henan, China)