

EEM 214

ELEKTRONİK I

Lecture 1

Yrd. Doç. Dr. Derya Yılmaz

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DERSİN KODU / ADI	: EEM214-02 ELEKTRONİK I
ÖĞRETİM ELEMANI	: Yrd. Doç. Dr. Derya YILMAZ
DERS SAATLERİ	: Pazartesi 13:00-14:50 Cuma 09:00-10:50 LAB-01 Salı 11:00-12:50 LAB-02 Salı 15:00-16:50
OFİS SAATLERİ	: Pazartesi 11:00-11:50 Cuma 13:00-13:50 Ofis: D404
DERSİN WEB SAYFASI	: http://moodle.baskent.edu.tr
DERS KAYNAKLARI:	-Microelectronic Circuits 6th Edition, Adel S. Sedra ve Kenneth C. Smith, Oxford University Press. -Microelectronic Circuit Design, 4/e Richard Jaeger ve Travis Blalock, McGraw-Hill Publishing.
EK KAYNAKLAR:	-Electronic Devices and Circuit Theory 10th Edition, Robert L. Boylestad ve Louis Nashelsky, Pearson Publishing. -Microelectronics Circuit Analysis and Design 4th Edition, Donald M. Neamen, McGraw-Hill Publishing. -KC's Problems and Solutions for Microelectronic Circuits Fourth Edition, Kenneth C. Smith, Oxford University Press. -Laboratory Explorations for Microelectronic Circuits, Kenneth C. Smith, Oxford University Press.

NOTLANDIRMA:

Lab	Quiz	Ödev	Arasınav	Yarıyıl Sonu Sınavı	TOPLAM
15%	20%	5%	25%	35%	100%

HAFTA	KONULAR
1	Atomun yapısı, yarıiletken maddeler, P ve N tipi madde
2	Diyotlar, diyot uygulamaları
3	Temel düzengeç devreleri
4	Zener diyot, diğer diyot çeşitleri
5	BJT transistörlerin yapısı, özellikleri
6	CE, CB, CC yükselteç devreleri ve öneğilimleme
7	BJT transistörlerde küçük sinyal modeli, kazanç, giriş-çıkış empedansları
8	ARASINAV
9	FET türleri, yapıları, özellikleri
10	FET yükselteç devreleri ve öneğilimleme
11	FET transistörlerde küçük sinyal modeli, kazanç, giriş-çıkış empedansları
12	Çok katlı yükselteçler, Kaskat ve kaskod bağlantı
13	Mikroelektronik yaklaşımla yükselteç devreleri, Akım kaynak devreleri ve transistörleri akım kaynaklarıyla öneğilimleme
14	İşlemsel yükselteç iç yapısı

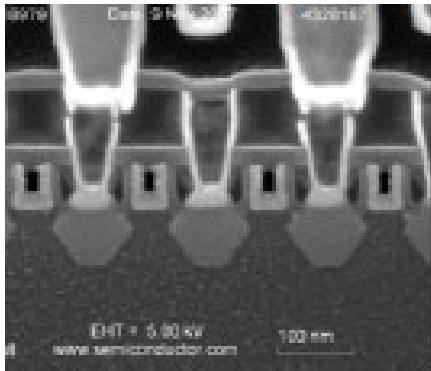
ÖNEMLİ NOT:

•Laboratuvar saatlerinin %20'den, ders saatlerinin de %30'dan fazlasına katılmayan öğrenciler dersten **F2** notu alırlar.

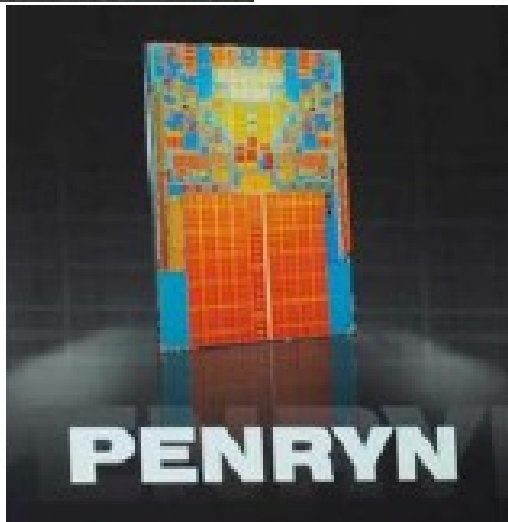
Applications

- Amplification
- Power control/conversion
- Switching
 - Discrete logic
 - Computers
- Signal generation (oscillators, etc.)
- Signal processing (demodulation, etc.)

Penryn Microprocessor



- Feature size: 45nm
(1 nm = 10^{-9} meter;
width of human hair =
100,000 nm)
- Operating speed: up to 3.2 GHz
- # of transistors:
 >800M for quad-core

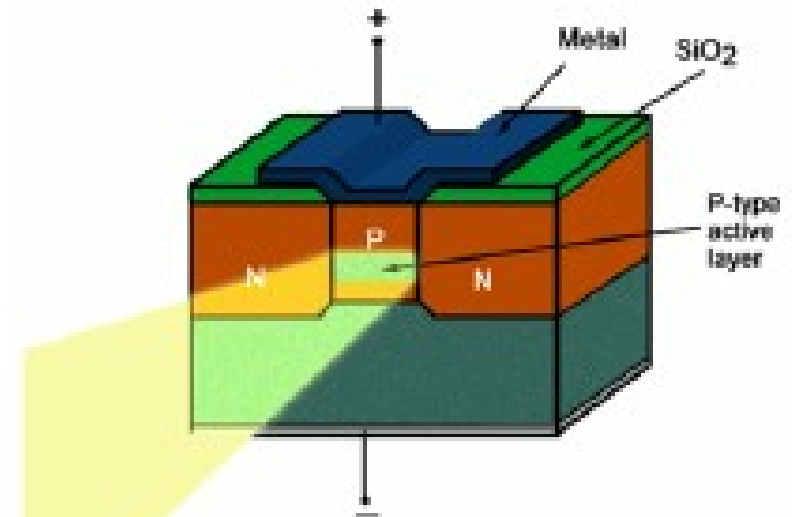


Laser diodes

- Ex. Pulsed laser diode, 860 nm, 5W



www.hamamatsu.com.uk

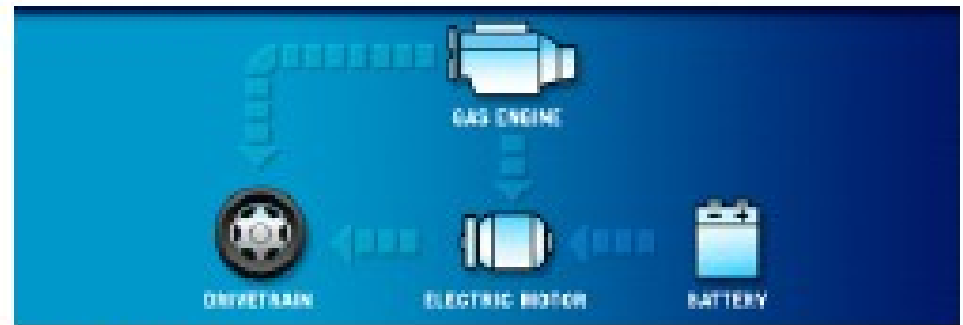


www.williams-adv.com

- Used in CD/DVD players, fiber optic communications equipment, laser pointers, instrumentation

Toyota Prius Hybrid Car

- Does 22 km/liter of gasoline
- Ultralow emissions

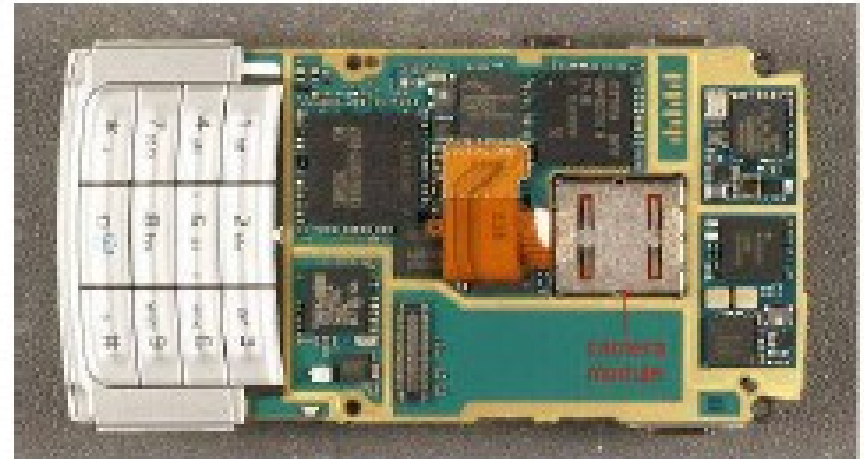


www.toyota.com

- Power electronics convert/control energy from motors/battery/gas engine

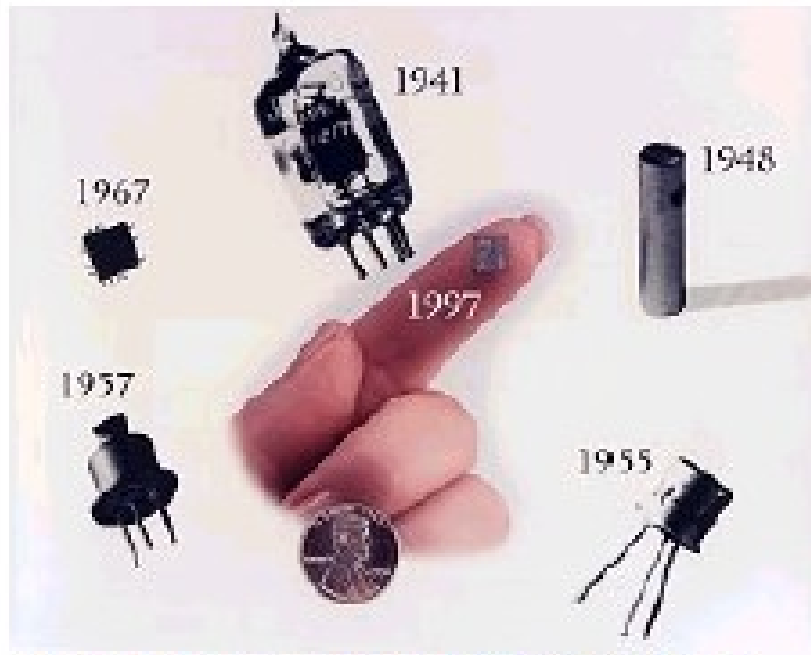
Cell phones

- Microprocessor
 - overall control
- DSP/ADC/DAC
 - process audio and baseband signals
- ROM and flash memory
 - programs and user info (directory, etc.)
- RF amplifiers
- Power management
- Liquid crystal display



http://www.chipworks.com/uploadedimages/Blog/Test_Blog/Nokia.jpg

History



www.bellsystemmemorial.com/belllabs_transistor.html

- An excellent multimedia tour is at www.pbs.org/transistor/

Vacuum tubes

- 1883: Edison effect - electrons travel through a vacuum to form current
- 1904: John Fleming invents Fleming valve - uses Edison effect to rectify AC current
- 1906: Lee De Forest invents Audion vacuum tube capable of amplification
- Short component life



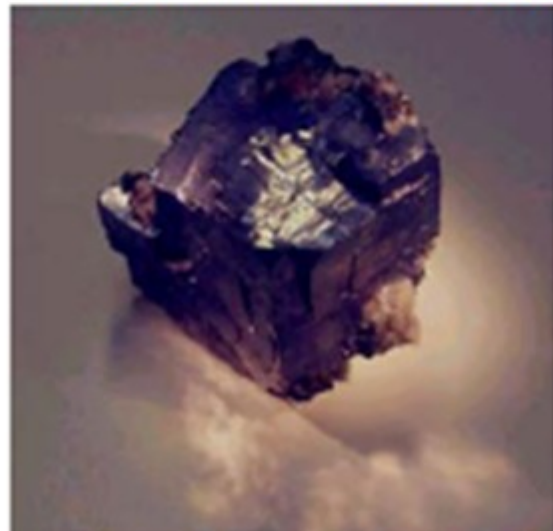
www.electron-valve.com/history/history.html
www.cedmagic.com/history/deforest-audion.html

Semiconductors

- Early 1900's: galena (crystalline lead sulfide) used as radio detectors (rectifying AC current)
- Point contact rectifier
- 1940: Russell Ohl discovers silicon p-n junction



www.sparkmuseum.com/DETECTOR.HTM



Transistor

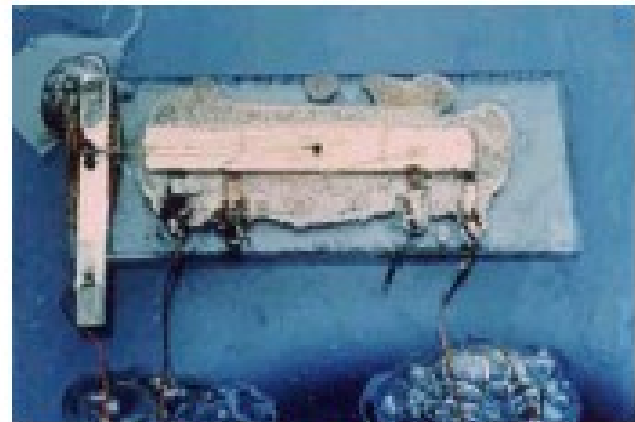
- 1947: Shockley, Bardeen, & Brittain invent transistor at Bell Labs (won Nobel prize in 1956)
- Point contact transistor using germanium
- Today, silicon transistors more popular because of excellent chemical properties (easier to work with)



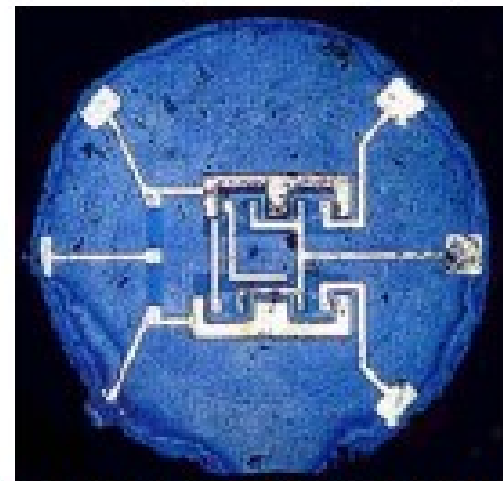
www.bellsystemmemorial.com/belllabs_transistor.html

Integrated circuits

- 1958: Jack Kilby and Robert Noyce invent the integrated circuit -- squeezing several components on a single chip of silicon
- A simple oscillator IC with five integrated components
- Early technology difficult to scale
- 1959: invention of planar IC technology (still used today in VLSI)



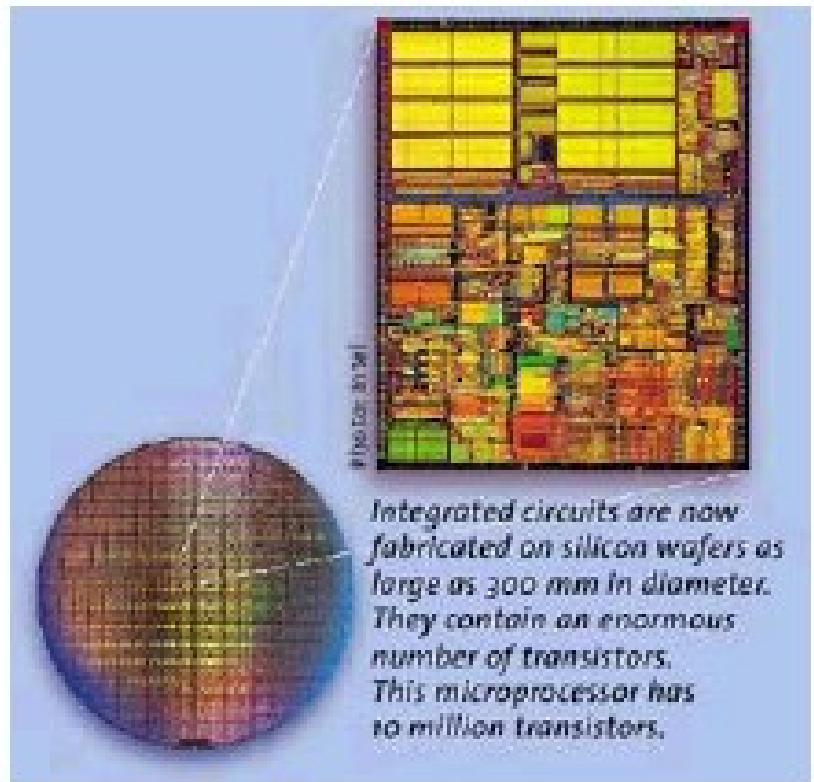
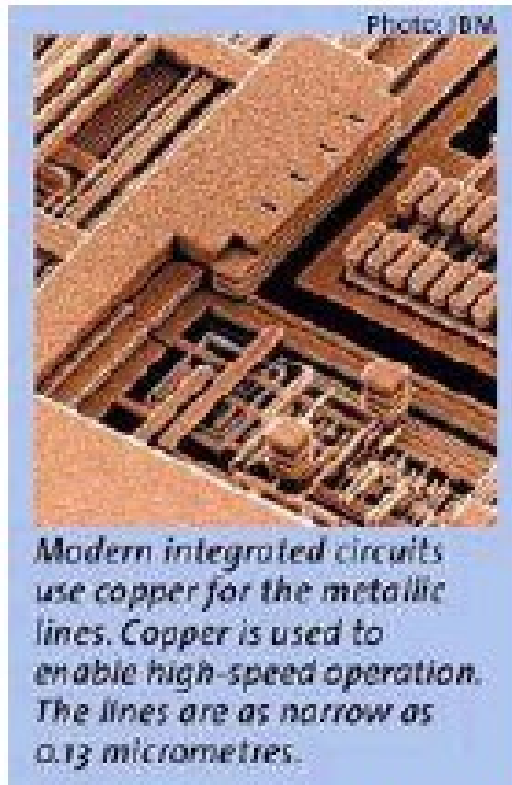
www.icknowledge.com/history/First_IC.jpg



www.icknowledge.com/history/Noyce_IC.jpg 11

VLSI

- Very Large Scale Integration

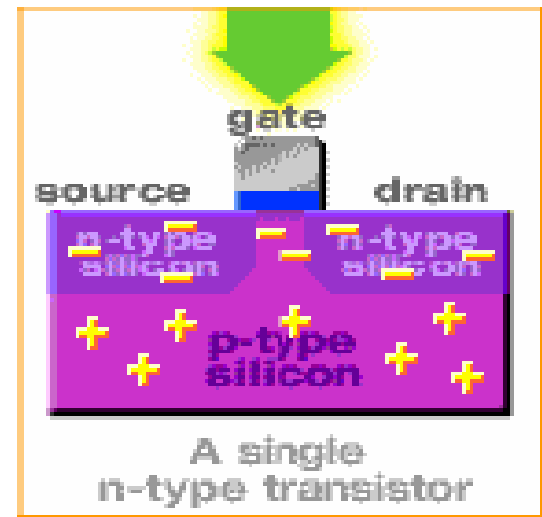
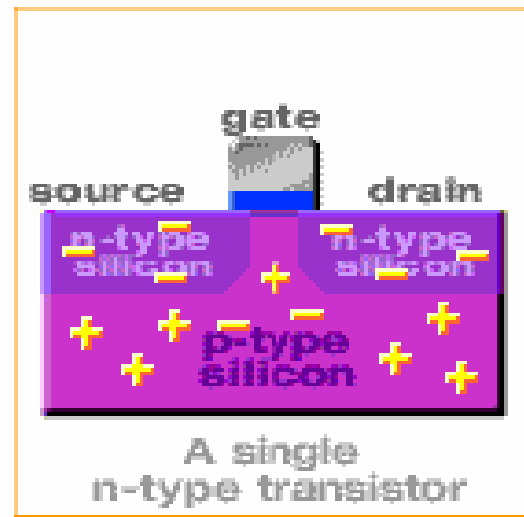
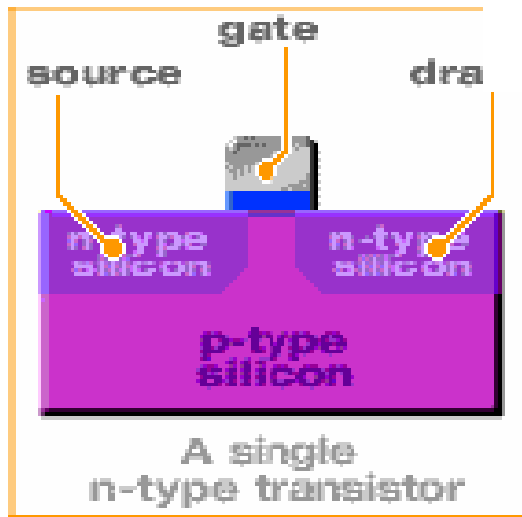


Transistor operation

N-channel
MOS FET
(field effect
transistor)
construction

No gate voltage:
no channel
between source
and drain

+ gate voltage
attracts
electrons and
forms channel

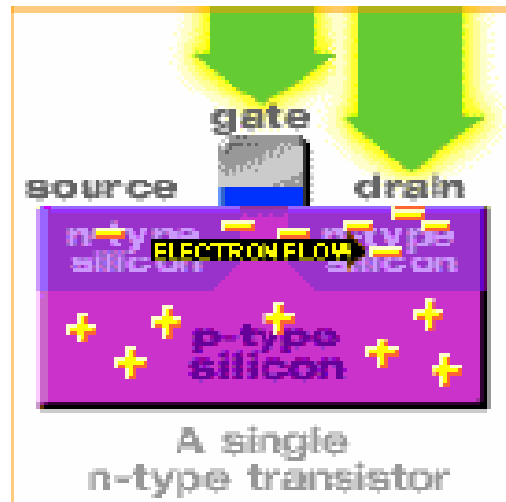


Transistor operation...

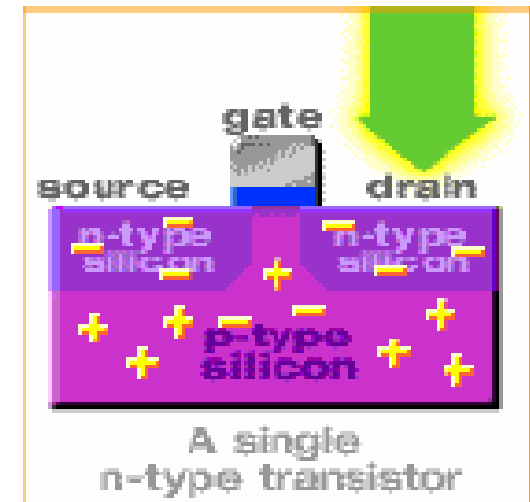
+ drain voltage
pulls in
electrons from
source through
channel

Removing gate
voltage destroys
the channel,
stopping electron
flow

ON



OFF



Problems with simple explanations

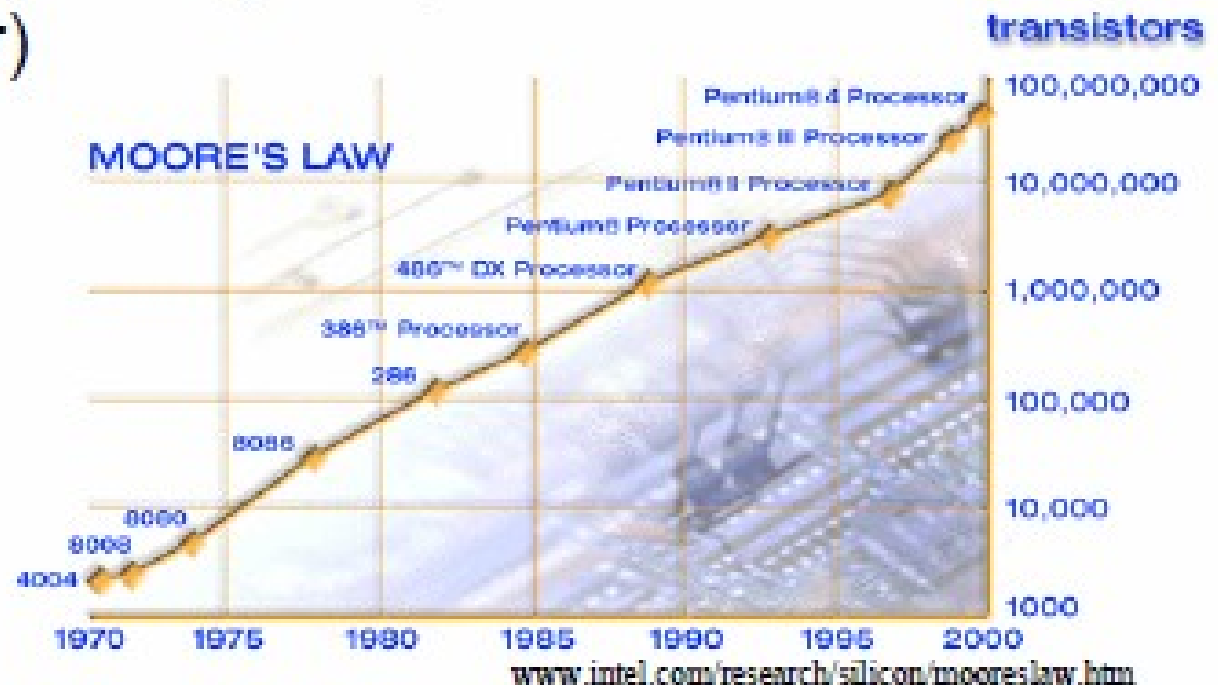
- Does not give detailed/quantitative device behavior useful in circuit design
- Does not allow us to predict performance of a device design
- Does not give us insight on how to build better devices

Technology metrics

- Density
- Speed
- Power consumption
- Power rating
- Noise

Density: Moore's Law

- Density of transistors in chip doubles about every 18 months (1965, Gordon Moore: Intel co-founder)



Higher density = smaller feature sizes

**Silicon Process
Technology**

1.5 μ

1.0 μ

0.8 μ

0.6 μ

0.35 μ

0.25 μ

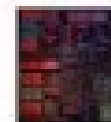
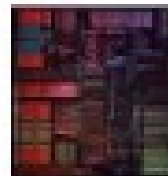
**Intel386™ DX
Processor**



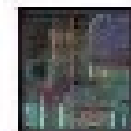
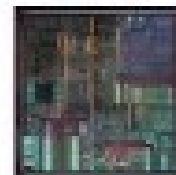
**Intel486™ DX
Processor**



Pentium® Processor

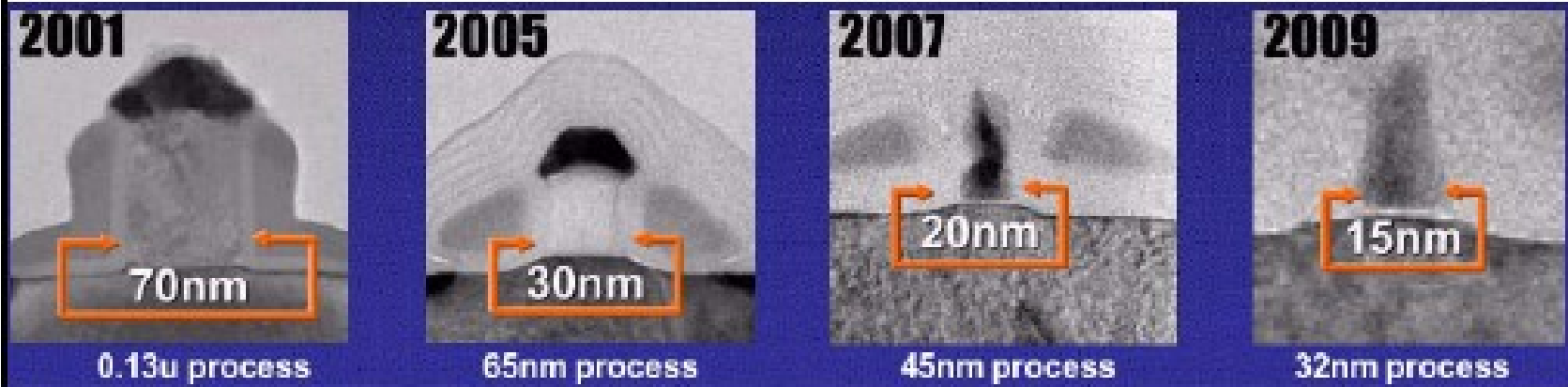


**Pentium® Pro &
Pentium® II Processors**



www.intel.com/update/archive/issue2/pix/foc_fig3.jpg

The vanishing transistor

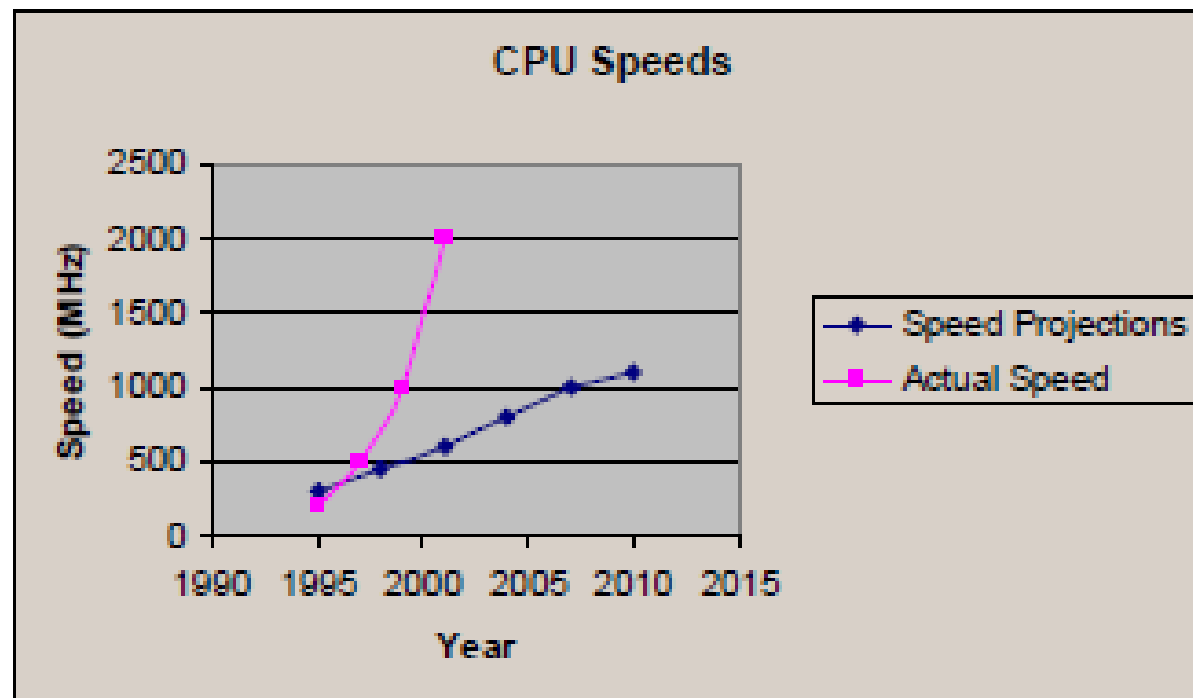


Intel

- Difficulties in performance, reliability, mass-production as feature sizes shrink; addressed by new topologies/processes

Speed

- Factors: size, material, design

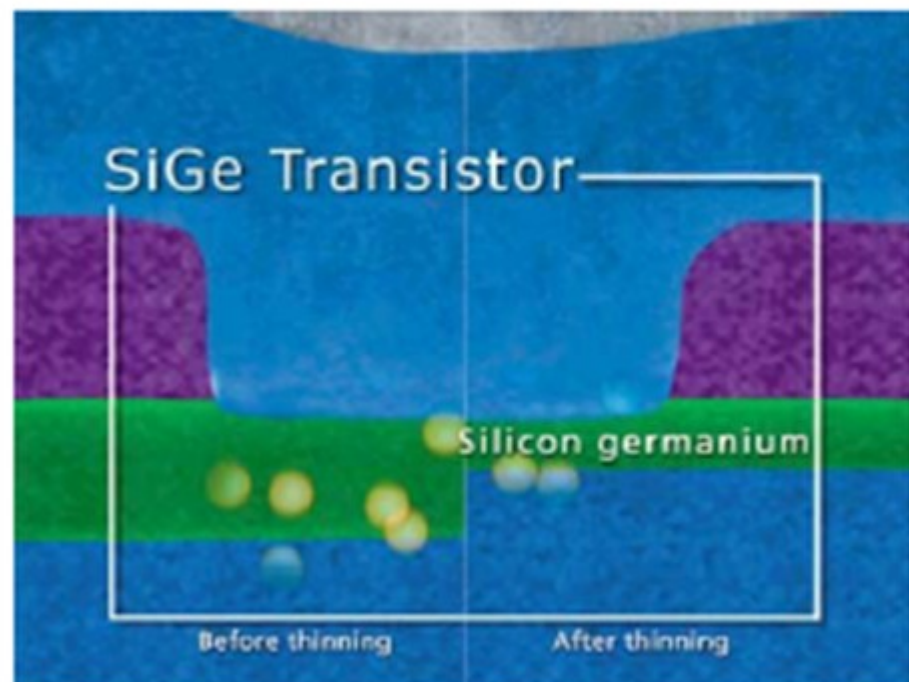


Actual speed data from www.dell.com/us/en/esg/topics/power_ps3q02-intelgb.htm.

Speed projections from R. Pierret, "Semiconductor Device Fundamentals", Addison-Wesley, 1996.

The fastest transistor?

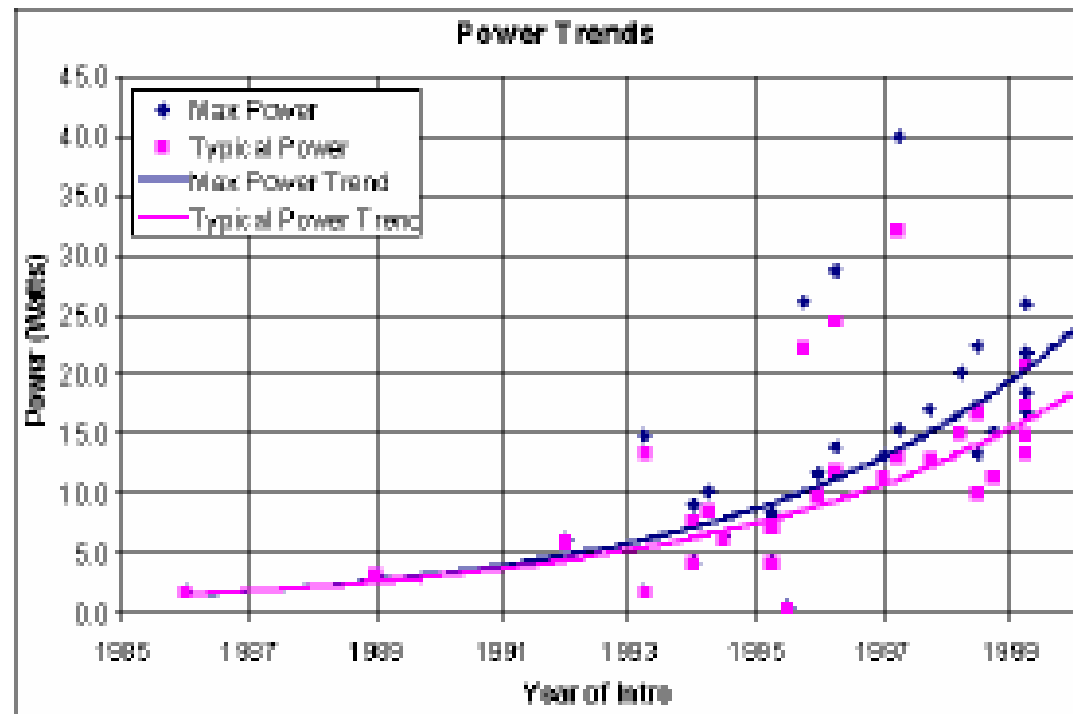
- Silicon germanium (SiGe) transistor that can operate at 210 GHz. (IBM, 2001)
- SiGe, GaAs and other mat'ls faster than silicon alone. Other design features help achieve speed.



www-3.ibm.com/chips/news/2001/0625_fastimages.html

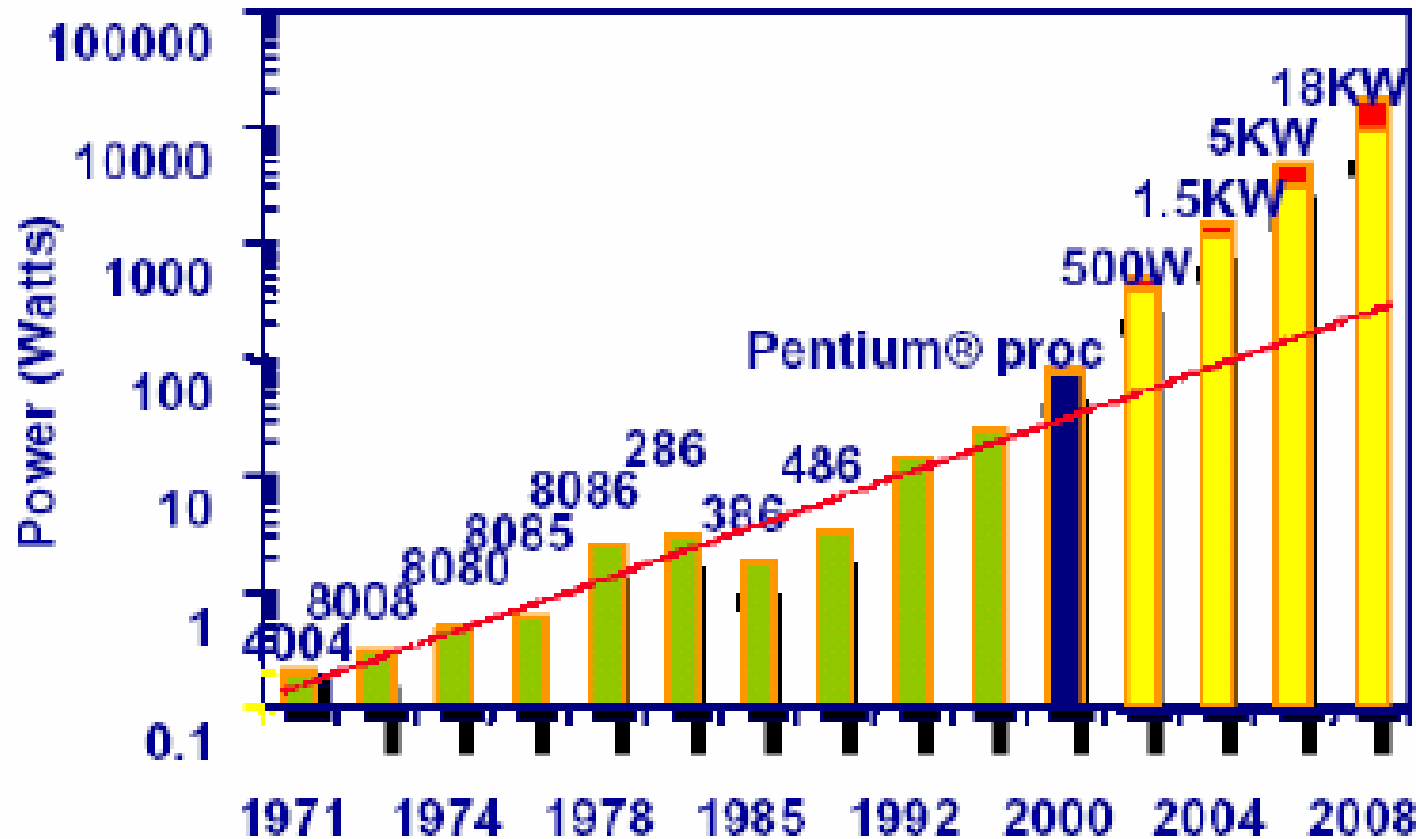
Power consumption

- Power $\propto$ (frequency)²
- Power $\propto$ (supply voltage)²



www.intel.com/technology/itj/q12001/articles/art_4.htm

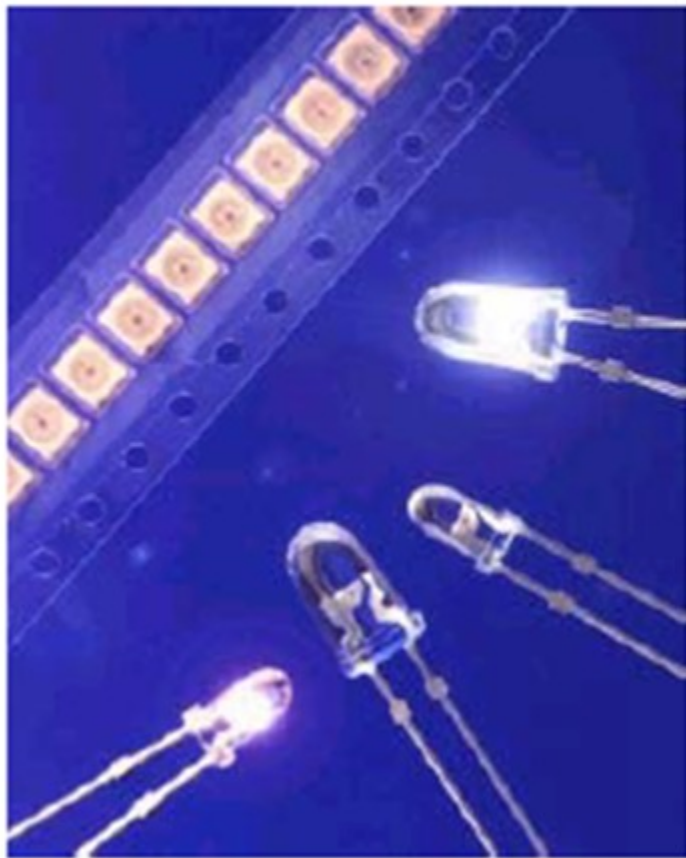
Power dissipation: future problem



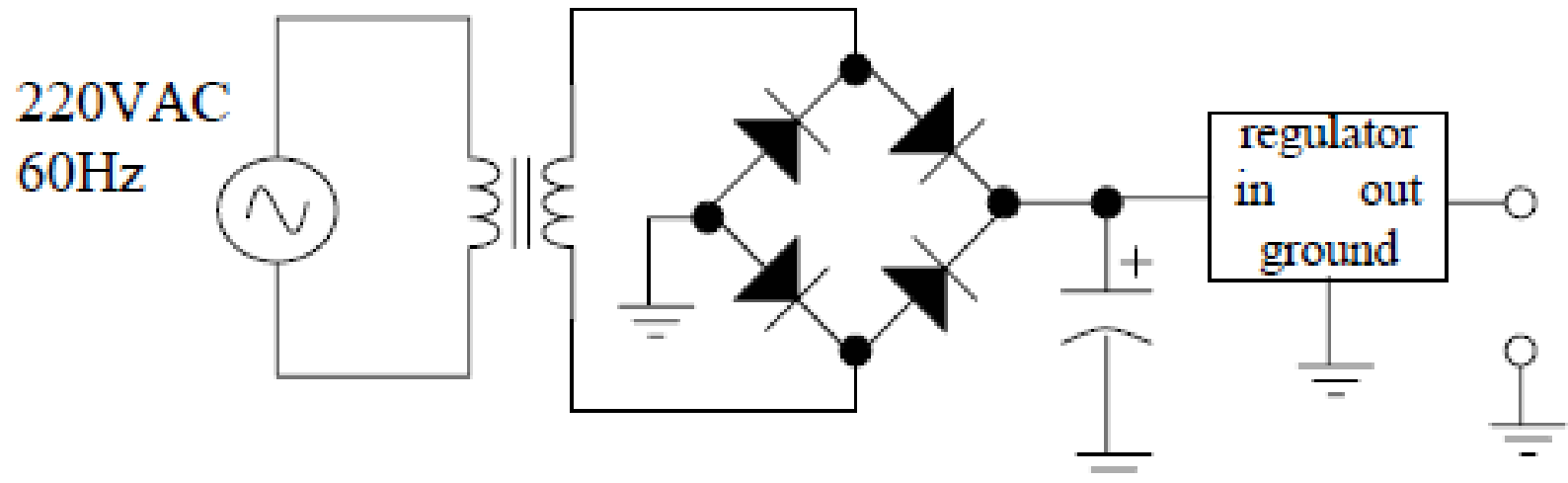
S. Borkar

White LEDs

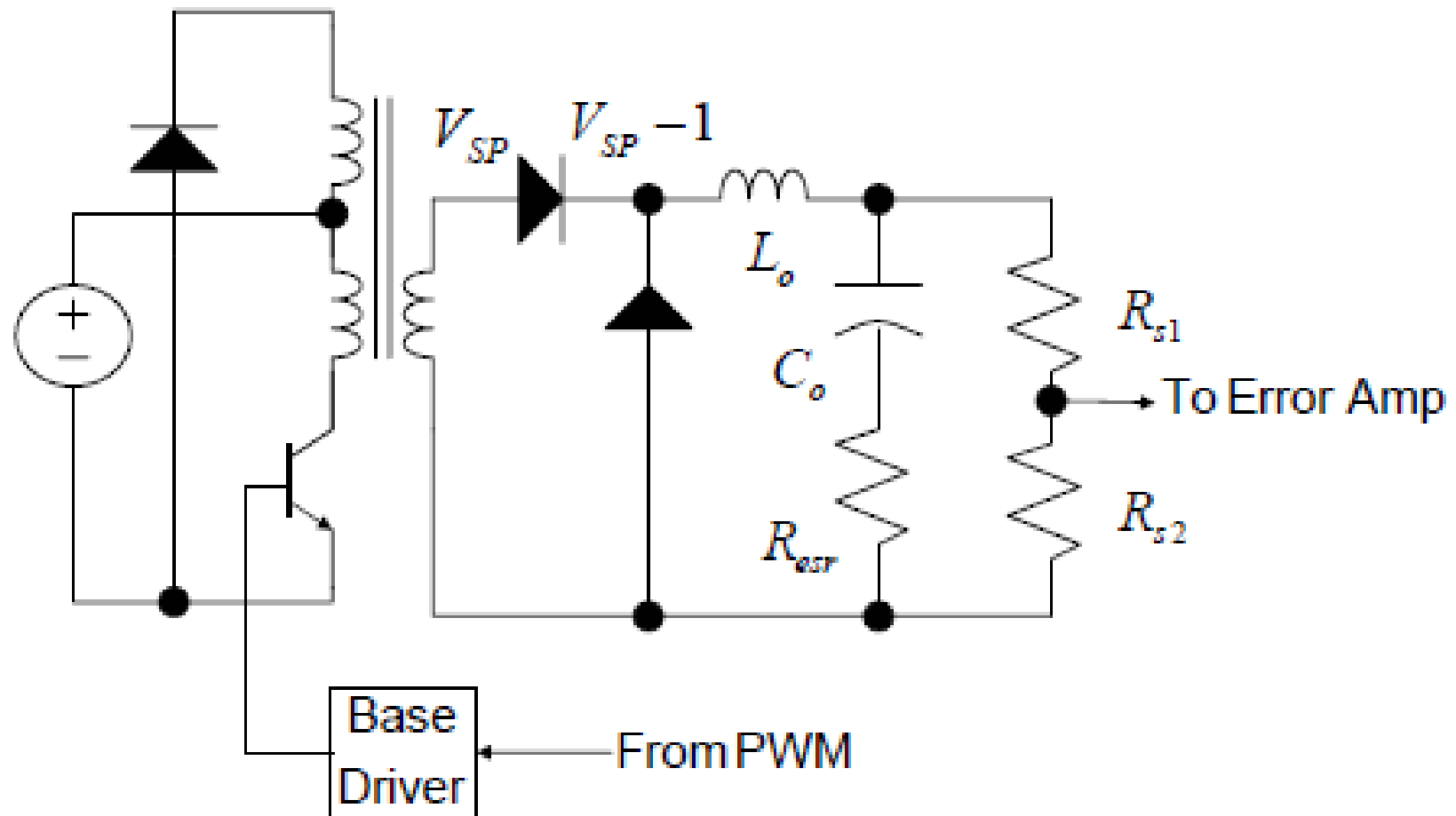
- Composition determines color
- Red: Ga, As, P
 - earliest sale 1970's
- Green: Ga, P, N
- Blue: Ga, N
 - first sold 1994
 - made white/full-spectrum LEDs possible



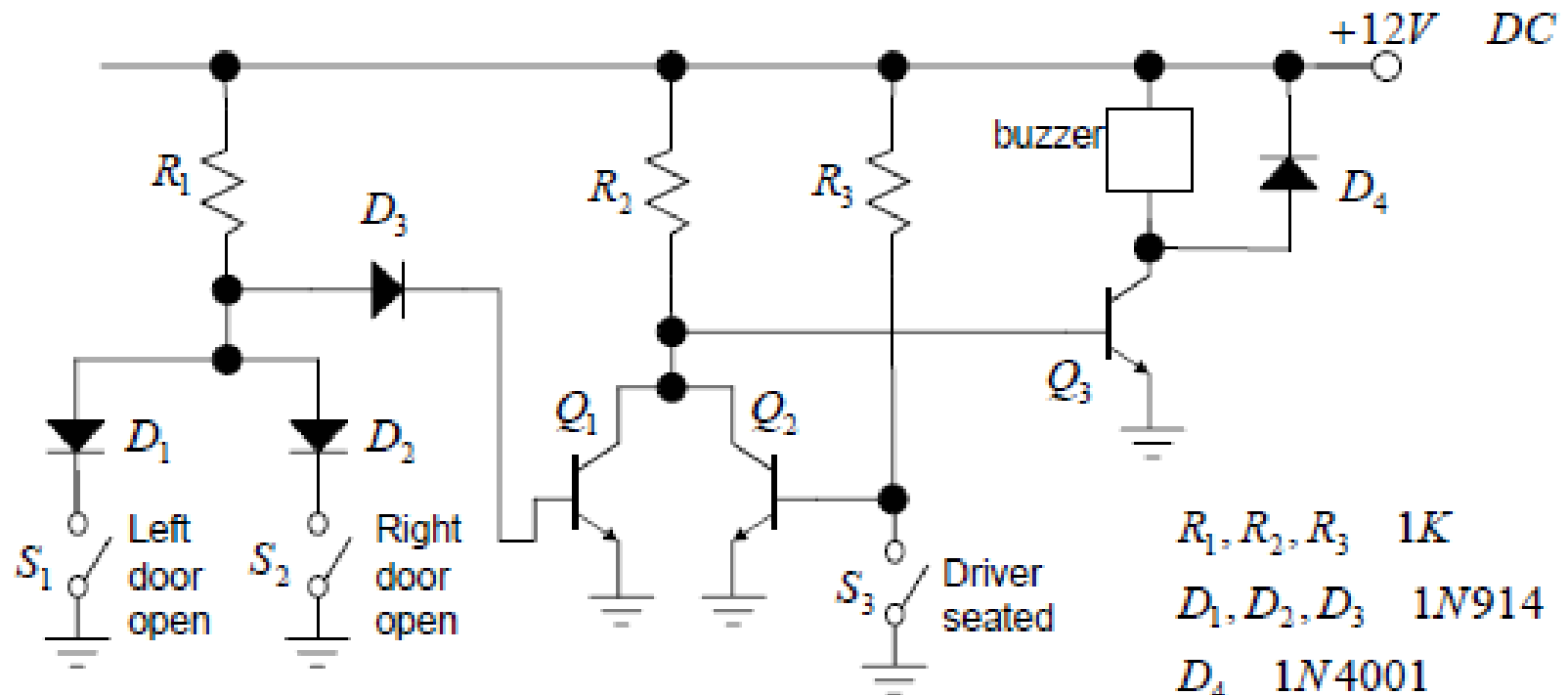
Basic power supply



Forward converter



BJT logic



R_1, R_2, R_3 1K

D_1, D_2, D_3 1N914

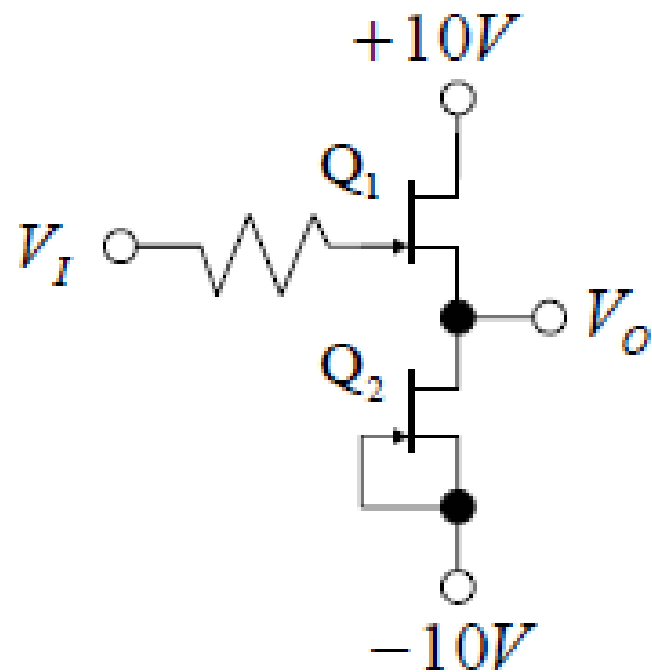
D_4 1N4001

Q_1, Q_2 2N3904

Q_3 2N3725

FET circuits

JFET Voltage follower



CMOS NAND gate

