
Welcome

ELECTRONIC DEVICES

EEE/ECE/INSTR F214

RAMESHA C K - IC

Abhijit Pethe- Instructor

Chembian Thambidurai- Instructor

Objectives of EEE F214 / INSTR F214

1. Solid understanding of the basic physical phenomena

- Carrier transport (drift and diffusion)
- Carrier generation and recombination
- Carrier injection and extraction
- Minority versus majority carrier type devices
- Energy band diagrams

2. Solid understanding of mainstream Integrated Microelectronic devices

- *p-n diode*
- *BJT*
- *MOSFET*
- *Schottky diode*

Course description

Text Book:

"Solid State Electronic Devices",

B.G.Streetman & Sanjay Banerjee, 6th ed., PHI, 2006

Reference Books:

(i) Introduction to Semiconductor Materials and Devices
M.S.Tyagi, John Wiley, New York, 1991.

(ii) Device Electronics for Integrated circuits
R.S. Muller & T.I. Kamins 3rd Ed., John Wiley,

(iii) Semiconductor Devices, Physics & Technology,
S.M.Sze, 2nd ed., Wiley.

Course plan

Lect. No.	Topic	Learning objectives	Book reference
1-3	Semiconductor materials, crystal properties and growth of the semiconductor	Understanding of Crystal lattices, Crystalline and Amorphous solids, Different techniques of crystal growing.	SB 1.1 – 1.4,
4-6	Elementary quantum mechanics	The uncertainty principle, Schroedinger wave equation, step potential, potential well, and Tunneling.	SB 2.4
7-10	Electrical conduction in solids and statistical mechanics	Periodic potential, allowed and forbidden energy bands, Density of states, Direct and indirect band gap semiconductors, effective mass. Statistical distributions, Fermi-Dirac distribution function, Fermi energy.	SB 3.1 – 3.2
10-11	Charge carriers in semiconductors, Effect of electric and magnetic fields on drift of carriers	Fermi level, equilibrium carrier concentrations, mobility, Hall effect	SB 3.3 – 3.5

12-15	Excess carriers in semiconductors	Luminescence, Einstein's relation, continuity equation, Haynes-Shockley experiment	SB 4.1 – 4.4
15-21	Junctions	pn junction, IV characteristics, breakdown diodes, Schottky barriers, Ohmic contacts	SB 5.2 – 5.5.4, 5.6-5.7
22-27	Field Effect Transistors	Junction FET, MISFET, MOS capacitor, MOSFET	SB 6.2 – 6.5
28-33	Bipolar junction transistors	BJT operations, amplification, carrier distribution, I-V characteristics etc	SB 7.1,7.2, 7.4 – 7.7.4, 7.7.6-7.8.3
34-37	Optoelectronic Devices	Photodiodes, solar cells, LEDs and Lasers, Semiconductor Lasers	SB 8.1 – 8.4
37-38	High frequency and high power devices	Tunnels Diodes, IMPATT Diodes, GUNN Diodes, p-n-p-n Diode, SCR diode, IGBT	SB 10.1 – 10.6
38-40	Compound semiconductor devices	Compound semiconductors; HBT and HEMT	Lecture notes

Evaluation Scheme:

No.	**Component**	Duration	Marks	Date
1	Mid-Sem (Closed book)	90 min	30%	09/10/18, Tuesday 11:00 AM - 12:30 PM
2	Assignments/Tests/ Tutorials *	----	30%	Regular (open Book /Closed book)
3	Comprehensive exam (Closed book)	3 hours	40%	03/12/2018 2:00 pm - 5:00 pm

* It is compulsory to attend all the classes. Regular Attendance will be taken during Tutorial classes. Around 6% to 9% weightege will be given for attendance. In Addition to this surprise Quizes also will be conducted.

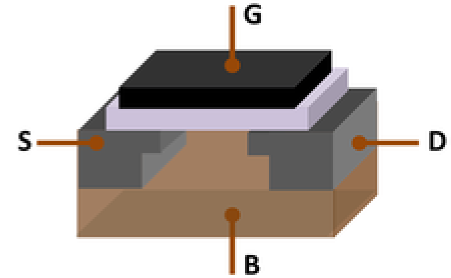
6. Tutorials :
Assistance will be provided in solving the problems asked in tutorial sheets.

7. Make-up Policy:
Make-up will be given only for Medical cases, requiring hospitalization.

8. Chamber Consultation hours:

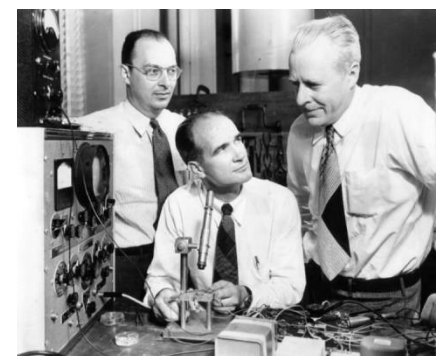
Ramesha C K   A 401/6   Tue   4:00 - 5:00 pm

- What is Electronics?
- What is Electronic Devices?



Sir John Ambrose Fleming (1849–1945) was an English electrical engineer and physicist, known primarily for inventing in 1904 the first **vacuum tube**. It was also called a thermionic valve, **vacuum** diode, kenotron, thermionic **tube**, or Fleming valve.

Bardeen, Brattain, and Shockley **invented** in 1947 was the first point-contact **transistor**.



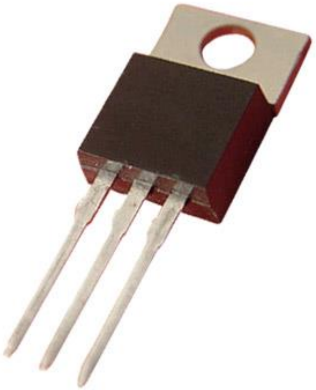
In 1959, Dawon Kahng and Martin M. (John) Atalla at Bell Labs invented the metal–oxide–**semiconductor field-effect transistor** (MOSFET) as an offshoot to the patented **FET** design.

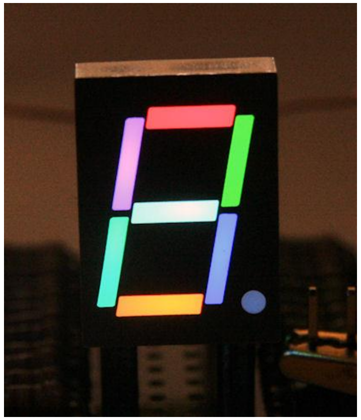
Today's Electronic Devices

020222_1335_0011
www.fotosearch.com

x28349948 fotosearch.com

k0680902 www.fotosearch.com





Semiconductor Material

- Semiconductors are a special class of elements having a conductivity between that of a good conductor and that of an insulator.
- They are fall into two classes : single crystal and compound
- Single crystal e.g Ge and Si
- Compound e.g GaAs , CdS, GaN and GaAsP

Group → ↓ Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

* Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
** Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Importance Semiconductor Devices

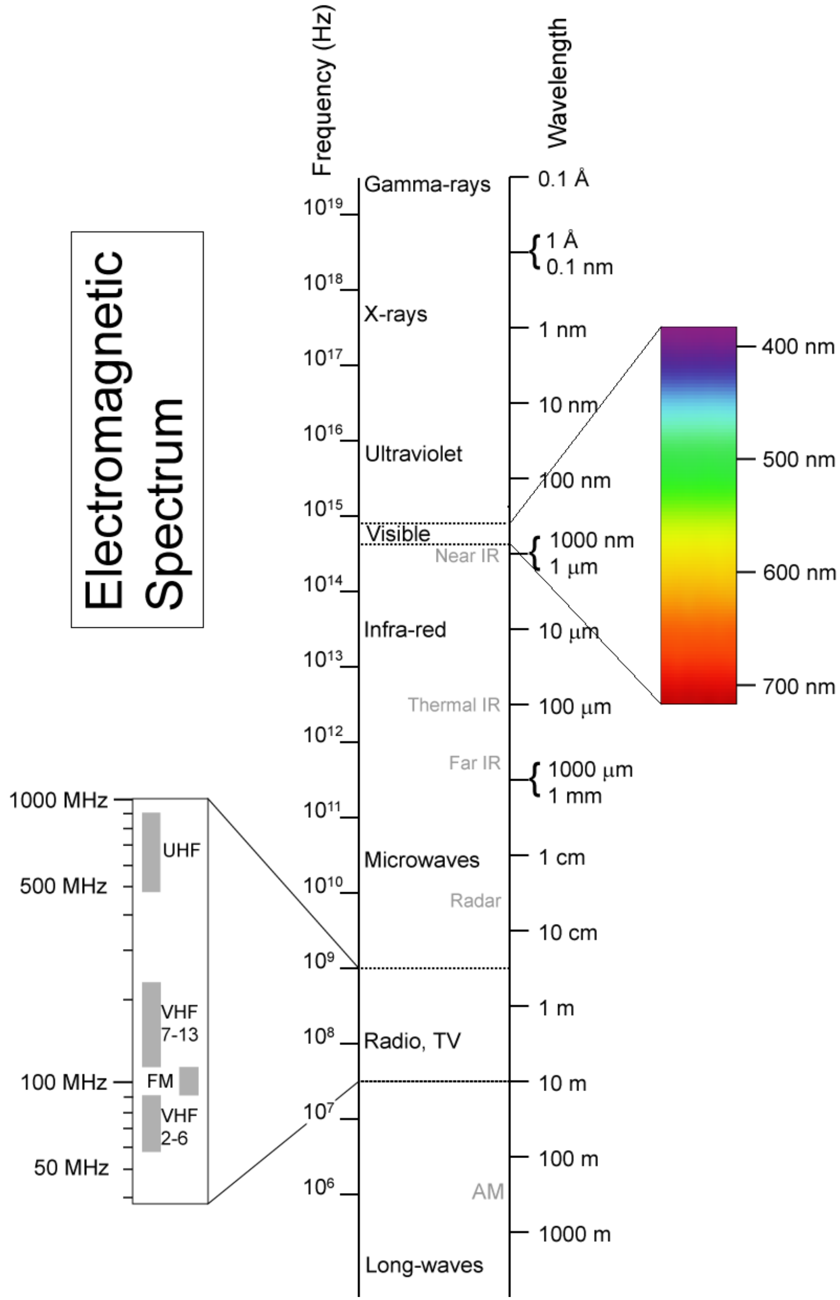
These devices enhance

- Performance
- Reliability
- Cost effectiveness

of

Energy Systems
Generate, distribute and regulate energy information

Information Systems
store, process and communicate


Electromagnetic Spectrum
Frequency (Hz)
Wavelength
Gamma-rays
X-rays
Ultraviolet
Visible
Near IR
Infra-red
Thermal IR
Far IR
Microwaves
Radar
Radio, TV
AM
Long-waves
10^{19}
10^{18}
10^{17}
10^{16}
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
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0.1 Å
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0.1 nm
1 nm
10 nm
100 nm
1000 nm
1 μm
10 μm
100 μm
1000 μm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1000 m
400 nm
500 nm
600 nm
700 nm
1000 MHz
500 MHz
100 MHz
50 MHz
UHF
VHF
7-13
FM
VHF
2-6

Course Objective

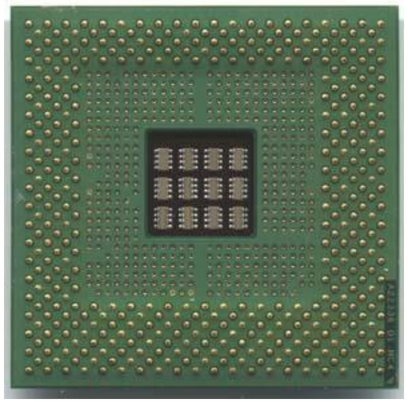
Terminal Characteristics ⟷ Material Parameters

DC I-V
AC I-V
Transient

Geometry
Doping
Energy gap
Mobility
Life time
Dielectric constant

Ambient conditions:
Temperature
illumination

Today's Electronic Devices



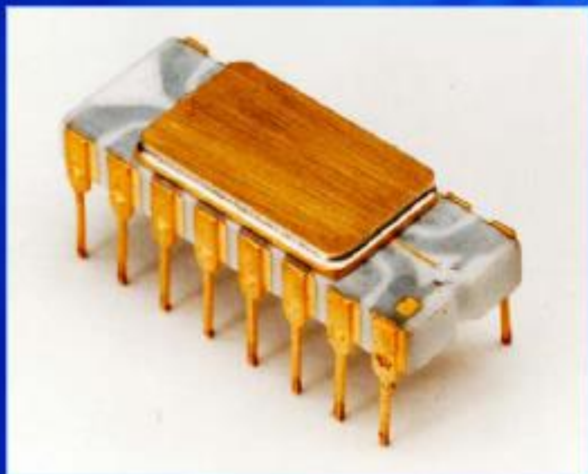
Front Back

INTEL Pentium IV processor

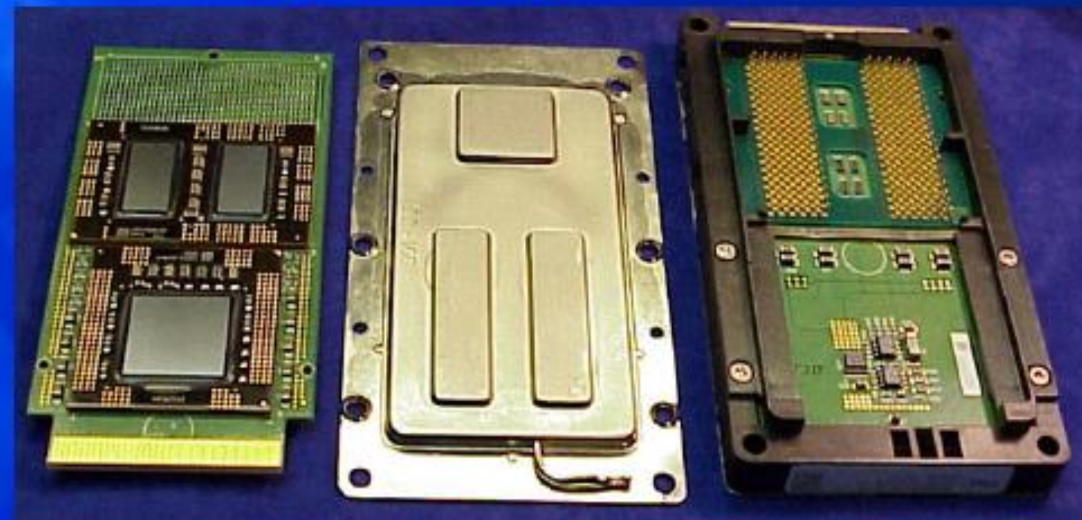
Take the cover off a microprocessor. What do you see?

- A thick web of interconnects, many levels deep.
- High density of very small transistors.

Evolution of Microprocesor Packaging



1971



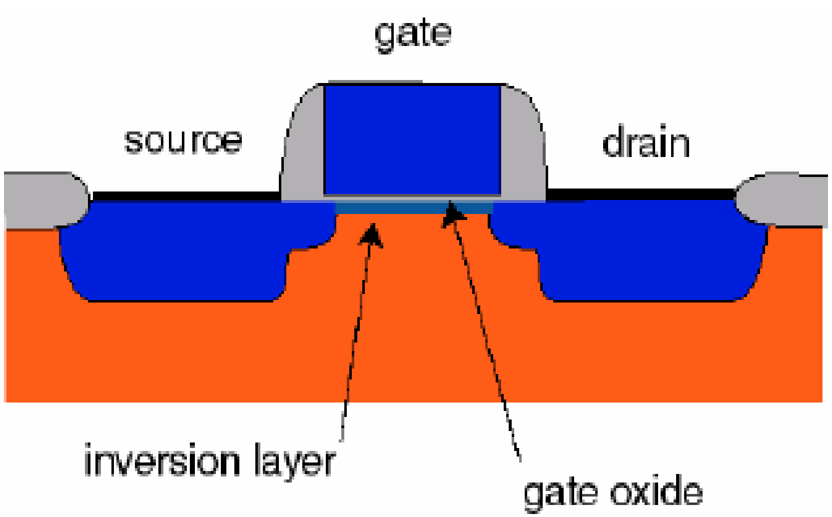
2001 onwards

PC Motherboard

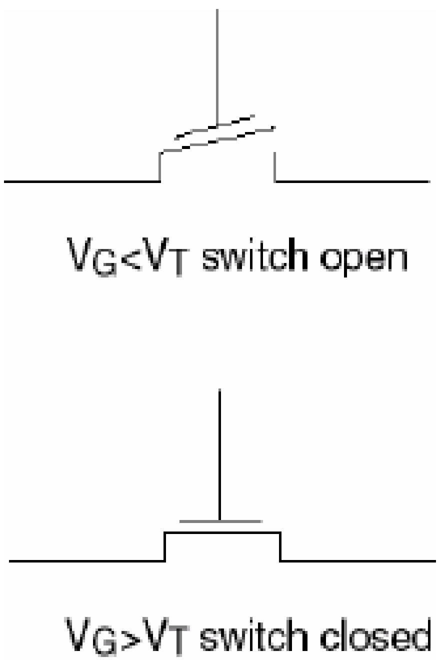
Keys to success: I. MOSFET

Metal-Oxide-Semiconductor

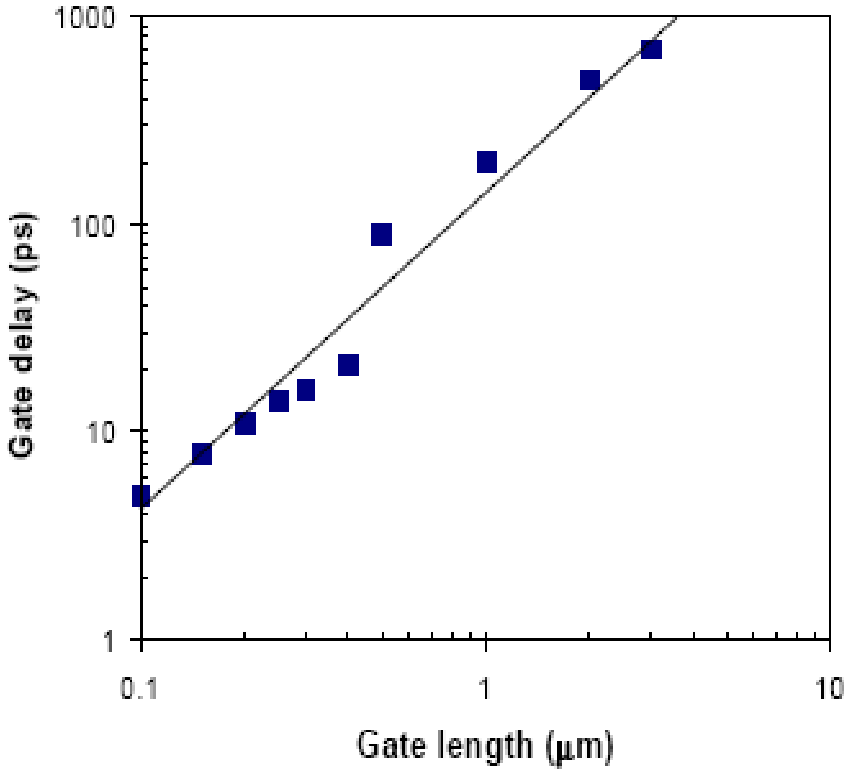
Field-Effect Transistor



MOSFET = switch



Keys to success: II. MOSFET scaling

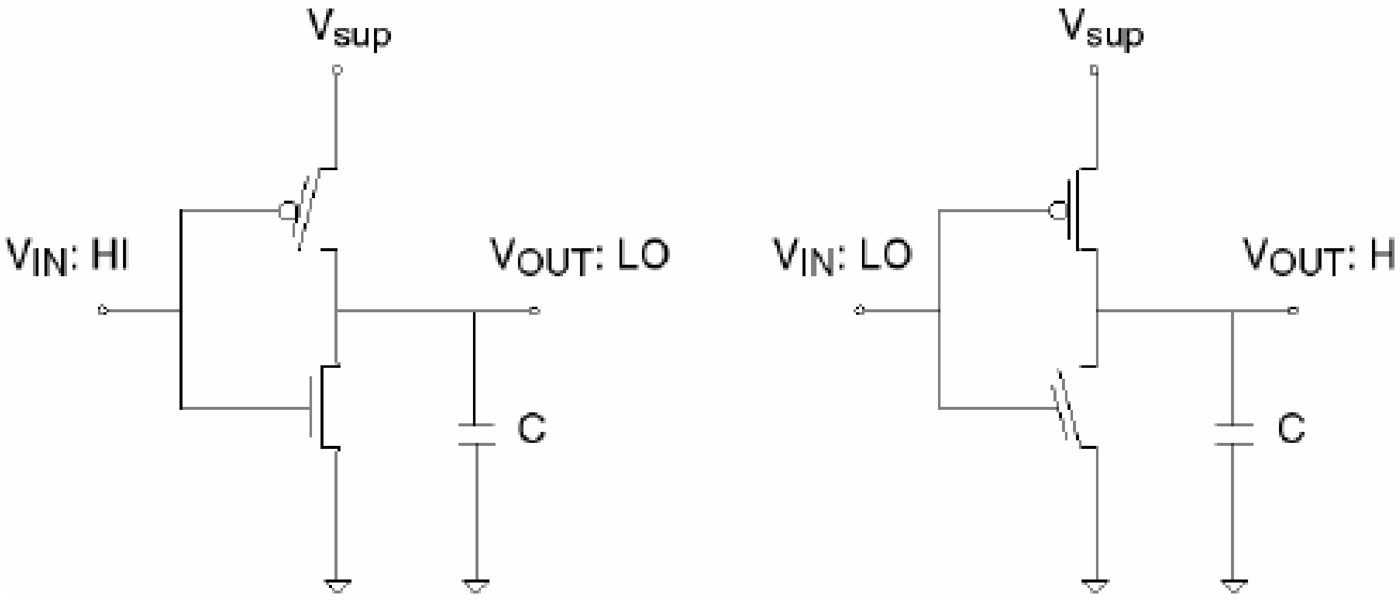


MOSFET performance improves as size is decreased:

- Shorter switching time
- Lower power consumption

Keys to success: III. CMOS

CMOS: Complementary Metal-Oxide-Semiconductor



- "Complementary" switch activates with V<0.
- Logic without DC power consumption.

SEMICONDUCTORS: They are here, there, and everywhere

• **Computers, palm pilots, laptops, anything "intelligent"**	Silicon (Si) MOSFETs, ICs, CMOS
• **Cell phones, pagers**	Si ICs, GaAs FETs, BJTs
• **CD players**	AlGaAs and InGaP laser diodes, Si photodiodes
• **TV remotes, mobile terminals**	Light emitting diodes
• **Satellite dishes**	InGaAs MMICs
• **Fiber networks**	InGaAsP laser diodes, pin photodiodes
• **Traffic signals, car taillights**	GaN LEDs (green, blue) InGaAsP LEDs (red, amber)
• **Air bags**	Si MEMs, Si Ics