

**EECS 1**

**Introduction to  
Electrical Engineering  
And Computer Science**

UCIrvine  
The Henry Samueli School of Engineering

1

**EE Specializations**

- Electronic Circuit Design
- RF, Antennas and Microwaves
- Semiconductors and Optoelectronics
- Digital Signal Processing
- Communications

UCIrvine  
The Henry Samueli School of Engineering

2


## EE Specializations

- Electronic Circuit Design
- RF, Antennas and Microwaves
- Semiconductors and Optoelectronics
- Digital Signal Processing
- Communications


UCIrvine  
The Henry Samueli School of Engineering

3

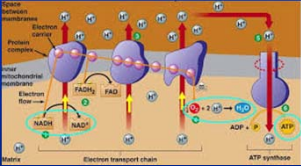
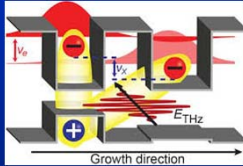
## Engineering is Based on Transport




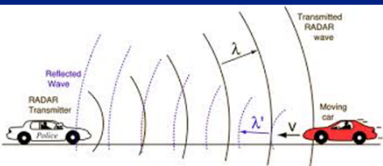
*The Miracle of Sound*



Mass Transport

Charge Transport

Energy Transport

The Henry Samueli School of Engineering

## Ways to Convey Message



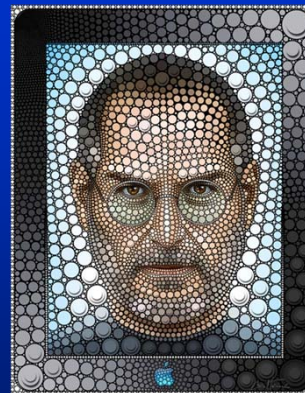
UCIrvine

The Henry Samueli School of Engineering

5

## Electronic or Optical Signaling

- You can convey the same message by using electrons or light
- Electronic or optical systems make devices that can produce meaningful result by controlling the electrons or photons (light)
- Semiconductors are class of materials that allows you to control motion and number of electrons and/or light (photon)



UCIrvine

The Henry Samueli School of Engineering

6

# Semiconductors

- Conductors:
  - Typically metals
- Very good conductivity of electricity
- Electrons flow from one end to the other end with low loss
- Insulators
  - Rubber, glass etc
- Very very poor conductivity
- Electrons can not flow through
- *Semiconductors: A material that can be switched from insulator state to conductor state by using electrical voltages or by other means such as light or heat.*

UCIrvine  
The Henry Samueli School of Engineering

7

# What are Semiconductors

Group:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period	1A	2A	3B	4B	5B	6B	7B	8B		1B	2B	3A	4A	5A	6A	7A	8A	
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] Unq	[105] Unp	[106] Unh	[107] Uns	[108] Uno	[109] Une	[110] Uun	[111] Uuu	[112] Uub	[113] Uut	[114] Uuq	[115] Uup	[116] Uuh	[117] Uus	[118] Uuo

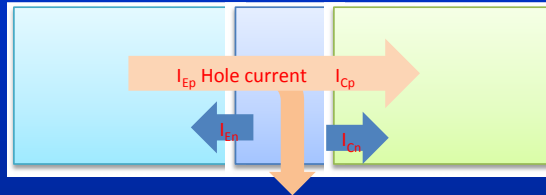
- There are materials from group II-VI elements on periodic table

UCIrvine  
The Henry Samueli School of Engineering

8

## What Does Semiconductor Do?

- The main job of semiconductors is to control and manipulate electron flow?



UCIrvinE

The Henry Samueli School of Engineering

9

## Applications

- Ge: Microwave diodes, **Substrate for growing GaAs and AlGaAs**
- Si: Diodes, transistors, integrated circuits (ICs) - Digital, analog, A-D, D-A, mixed mode, Computers, automobiles, communications & consumer electronics, Solar cells - watch, calculator, car, satellite, etc., Photodiodes for wavelength 0.4 to 1.0 $\mu$ m - optical receivers and detectors, Photodiode array with CCD (charge coupled device) - CCD camera, **Photodiode array with CMOS circuit – CMOS Imager**,
- C: Diamond or graphite**
- III-V GaAs: Microwave devices and ICs- satellite and wireless communications, radars
- $Al_xGa_{1-x}As/GaAs$ : Microwave devices and ICs, 0.60-0.9  $\mu$ m LEDs - displays, optical transmitters, light sources, 0.65-0.9  $\mu$ m laser diodes - laser printers, bar code scanners, CD players (750nm), fiber optic communications, space communications, light source (808nm)
- AlInAs/GaInAs/InP**: Microwave devices & ICs - High electron mobility transistors (HEMTs),
- GaInAsP/InP: - 1.5 $\mu$ m LEDs, laser diodes - fiber optic communications
- AlGaInP/GaAs: Visible laser diodes (shortest 620nm) - DVD (digital video disk, 635nm) Laser pointers,
- GaAsP/GaP: .55-.70 $\mu$ m LEDs - displays, light sources
- InGaN/GaN/sapphire**: High efficiency blue (450nm) and green (514nm) LEDs and lasers diodes - displays, light sources, green (505nm) traffic lights

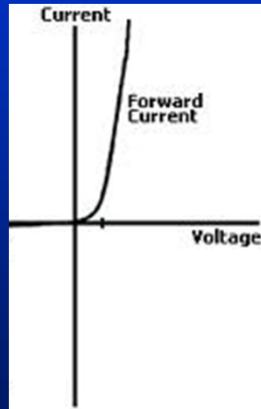
UCIrvinE

The Henry Samueli School of Engineering

10

## Diodes

- The most basic device you can make by using semiconductors
- It is a switch. In positive voltage it acts like a low resistance (a piece of metal wire)
- At negative voltages → Behaves like an insulator, no current flows
- It is used as rectifier → Helps to convert sinusoidal signals to DC signals



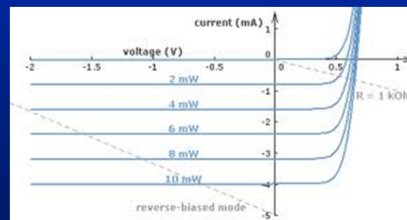
UCIrvine

The Henry Samueli School of Engineering

11

## Photo Diodes

- Similar to normal diode. Normally you apply negative voltage and hence it behaves like and insulator.
- When light shines on the diode → light is converted to electrons → Current flows
- Used in cameras, range finding, light detection



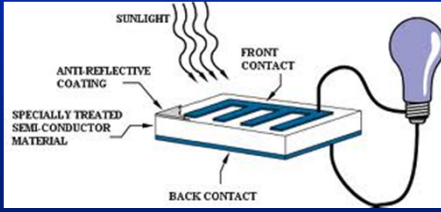
UCIrvine

The Henry Samueli School of Engineering

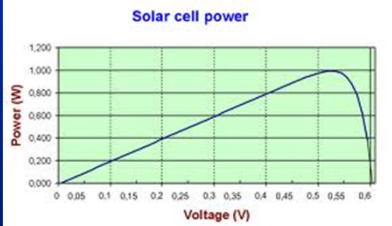
12

## Solar Cells

- It is a diode devices without voltage application → Free running device
- Incident light is converted into electrons
- Electrons are extracted by using internal dynamics to generate current



SUNLIGHT  
ANTI-REFLECTIVE COATING  
FRONT CONTACT  
SPECIALLY TREATED SEMI-CONDUCTOR MATERIAL  
BACK CONTACT




Solar cell power

**UCI**rvine  
The Henry Samueli School of Engineering

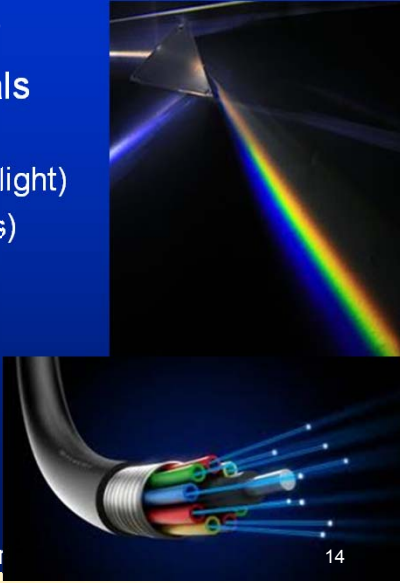
13

## What is Optics?

- Start with first word: Optics?
- Optics is a science that deals with light
  - Light can be visible light (sun light)
  - Or infrared (remote controllers)



REVERENDFUN.COM COPYRIGHT G4, INC.  
07-21-1999

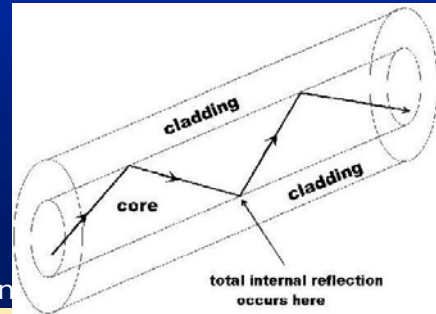
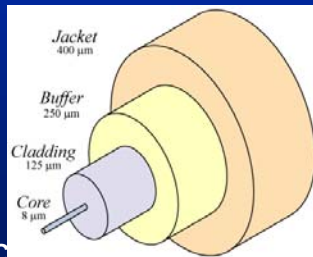


**UCI**rvine  
The Henry Samueli School of Engineering

14

## What can you do with light?

- Today, backbone of communication systems is optical communication.
- Light travels inside 9 $\mu\text{m}$  diameter core of glass fiber to carry information
- Light travels faster and longer distances in air or in glass than electrical signals in metals wires



UCI  
The Henry Samueli School of Engineering

## TAT-8

- In 1988 AT&T laid the first fiber-optic transatlantic telephony cable
- 3,148 miles long
- Connected North America to France
- Repeaters every 40 miles
- 565 Mbps bandwidth
- Used 1300 nm light
- Attenuation 0.4 dB/km



- Image from att.com
- Info from link Ch 1e
- [www.greatachievements.org/?id=3706](http://www.greatachievements.org/?id=3706)

UCIrvine  
The Henry Samueli School of Engineering



## How widespread are optical networks?

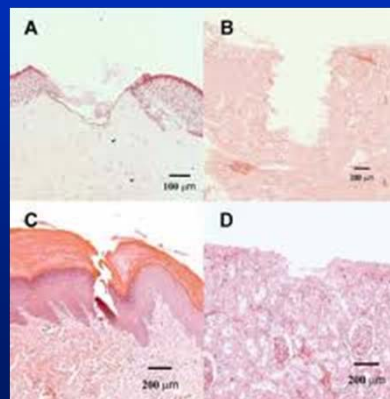


Ucc: Teleglobe

The Henry Samueli School of Engineering

## Laser

- Laser is a special kind of light source where all photons (light particles) are identical
- You can use lasers in material processing
- Biomedical applications
  - Tissue ablations
  - Dental works



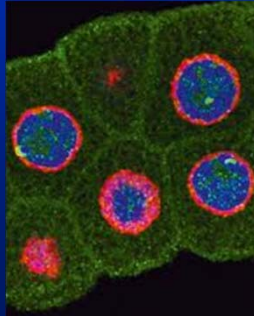
UC

The Henry Samueli School of Engineering

18

## Imaging: Biggest Field in Optics

- Imaging is biggest and also the oldest area of optics
- Imaging includes classical imaging heavenly objects to microscopy
- Technology seeks solution to problem of imaging wider area with utmost details
- Usually, imaging area and details (resolution) are contradictory



UCIrvine  
The Henry Samueli School of Engineering

19

## Military Applications

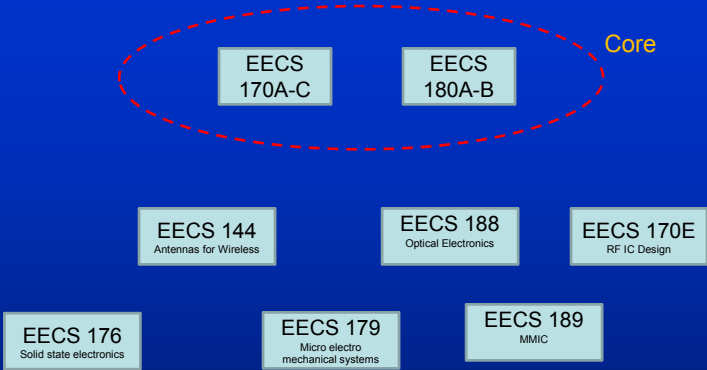
- Military applications is one of the largest batch of applications
- Laser Radar (Lidar)
- Free space communications
- Sensing
- Detection
- Targeting



UCIrvine  
The Henry Samueli School of Engineering

20

## Semiconductor/Photonics Courses











Core

**UCIrvine**  
The Henry Samueli School of Engineering

21




## People in the Area

Areas of specializations

- Semiconductors:
  - Analog/digital circuit design
  - Nano technology
  - Nano/bio technology
  - MEMS
  - RF Circuits
  - Antennas
- Optics/Photonics:
  - Lasers
  - Optical communications systems
  - Optical imaging
  - Magneto optics
  - Plasma optics
  - TeraHertz Applications

**UCIrvine**  
The Henry Samueli School of Engineering

22