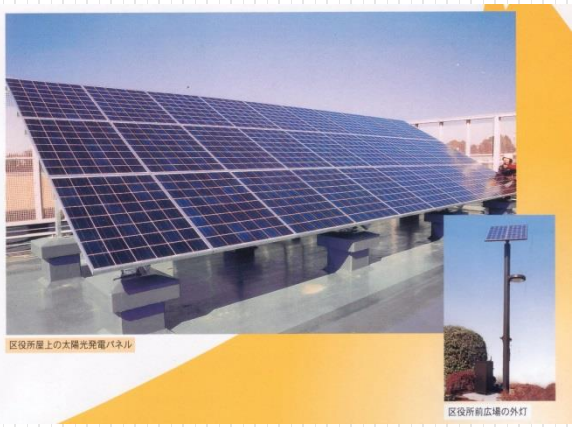
كلية الهندســـة بشبرا
FACULTY OF ENGINEERING- SHOUBRA
BENHA UNIVERSITY

Optical Communications
ECE423/ELE424/CCE507/ELE480

LEC (01)
Optoelectronics in your neighborhood

Dr/ Moataz M. Elsherbini
motaz.ali@feng.bu.edu.eg



LECTURE OUTLINES

1 – Basic definitions

2 - Optical Spectrum

3 - How many kinds of displays are found in the market?

4- Optical Disks

5 – Components of opto-electronics

6 – Integrated optical circuit (IOC)

7 - photonic integrated circuit (PIC)

8– Optoelectric integrated circuit (OEIC)

9- Why optical Communications needed?

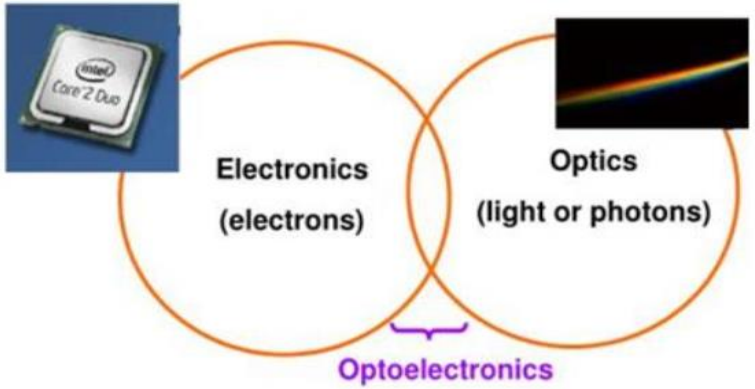
1 - Basic definitions

1 - Basic definitions

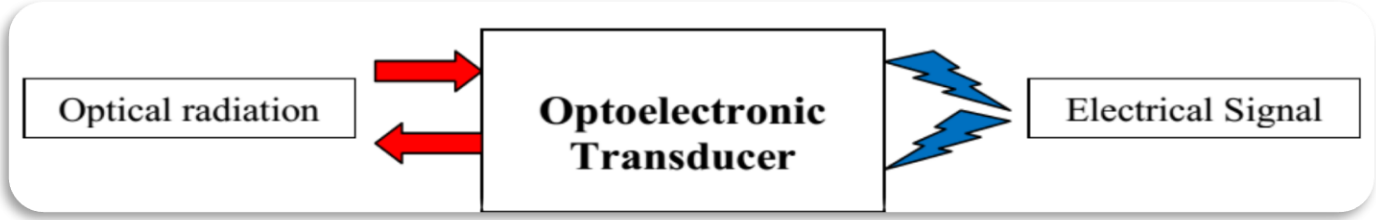
- **Optoelectronics** is a word combining optics and electronics, "**Japan**"
- **American** people prefer to use a term "optronics" or "electro-optics".
- **Optoelectronics** is the branch of technology concerned with combined use of electronics and light. It can be defined as the study and application of electronic devices that source, detect, and control light.
- Optoelectronics can be considered as the subfield of **photonics**
- **Photonics** is a technology related to "light", whose quantum unit is the photon. It includes the generation, emission, transmission, modulation, signal processing, amplification, detection, and sensing of light

1 - Basic definitions

- **Optoelectronic Devices :** Any device that operates as an electrical-to optical or optical-to-electrical transducer is considered an optoelectronic device.



- **In other words;** Optoelectronic devices are that category of transducers that deals with energy transformation from electrical to optical forms and vice versa when switching between input and output as shown in figure.

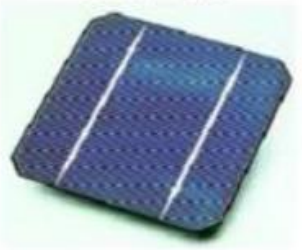


Examples of Optoelectronic devices

1. Photodiodes
2. Solar Cells
3. Light Emitting Diodes
4. Laser Diodes
5. Optical Fiber
6. Displays
7. Optical disks and flash memories

Photodiodes

Solar cells



LED

Telecommunication laser

Optical fiber

2 – How many kinds of displays are found in the market?

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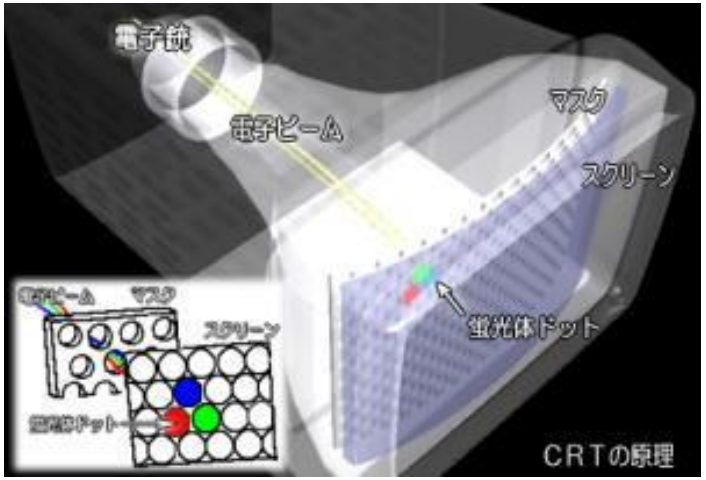

optical disks

- Read-only memory (ROM) type
- Rewritable (RW) or Random access memory (RAM) type
- CD-R (write-once)
- CD-RW(a rewritable memory / recording and erasing)
- DVD, HD-DVD
- MD (minidisk), MO (magneto-optical)➔ high re-writability more than 10^7 times
- Flash memory
- SSD… solid state drive

optical disks

- CD - DVD MD - MO

4 - Components of opto-electronics

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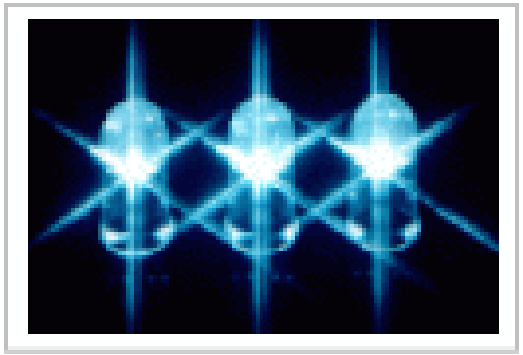
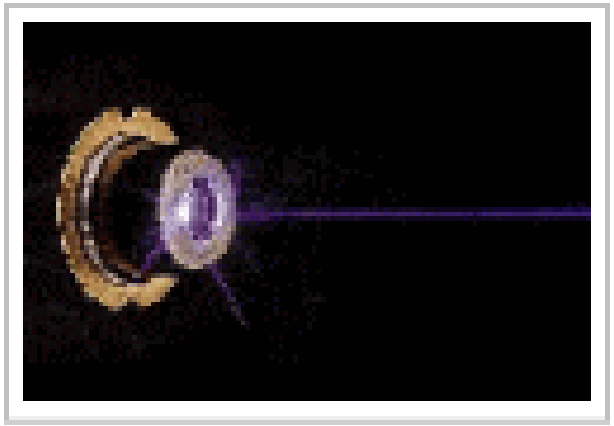


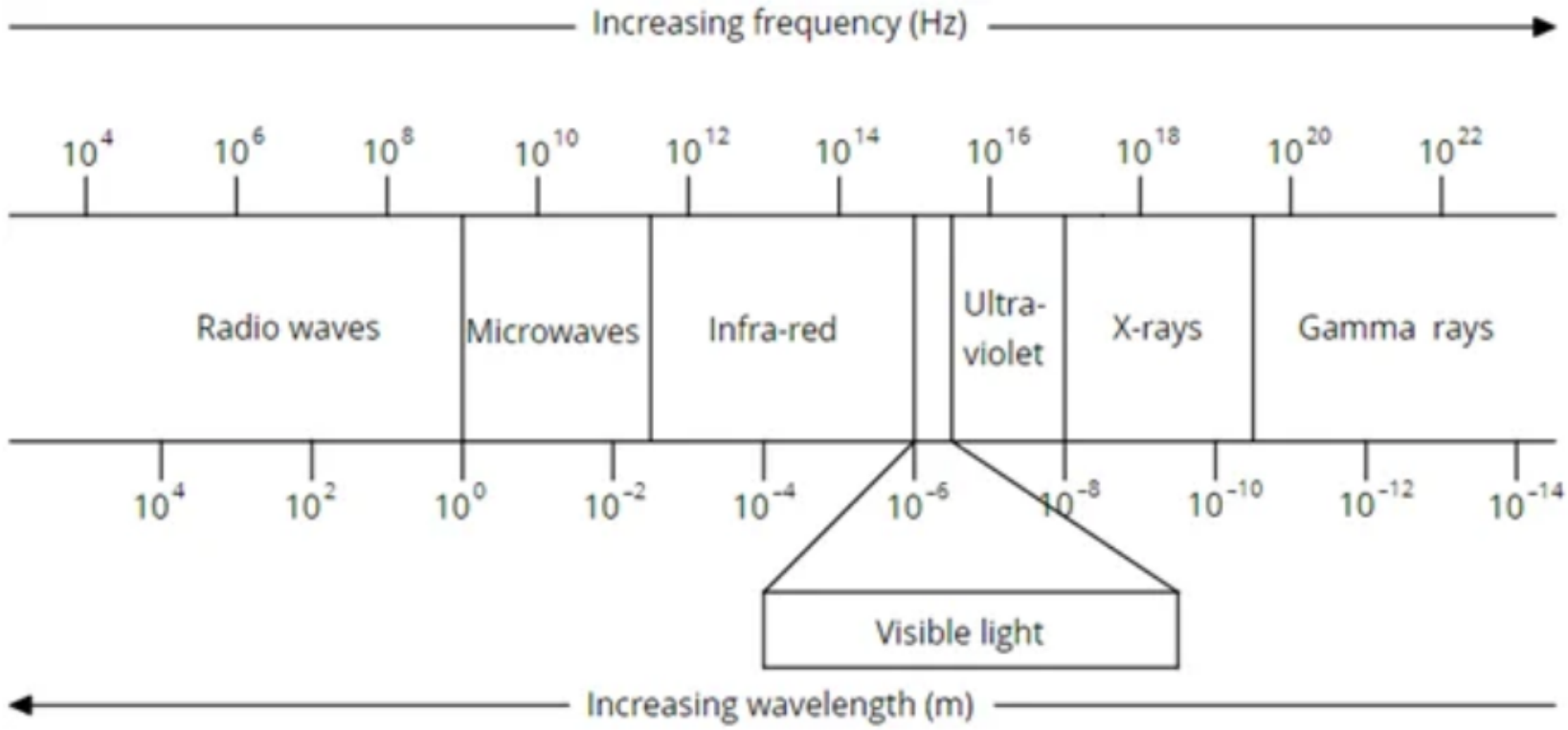
- Light emitting diodes (LED)
- Laser diodes (LD)
- Why and how these diodes emit light?
- To answer the question we need to understand;
  - PN junctions
  - Diodes
  - Other Semiconductors devices



physics underlying these semiconductor devices is necessary

5 – Optical Spectrum

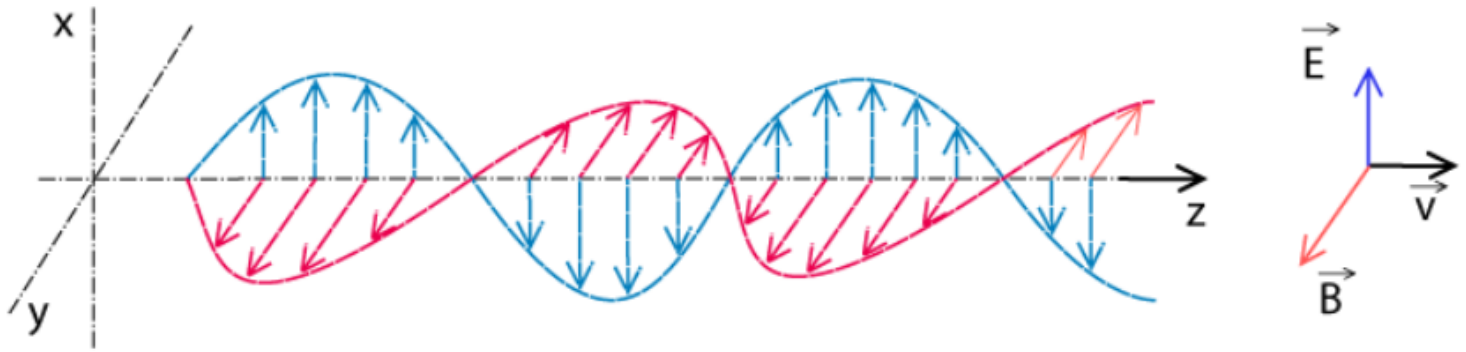
Electromagnetic spectrum and Optical Spectrum



- The **visible** wavelength region is between **380 nm** and **780 nm**
- Light whose wavelength is shorter than **380 nm** is called **ultraviolet**.
- Light whose wavelength is longer than **780 nm** is called **infrared**.

Optical Spectrum

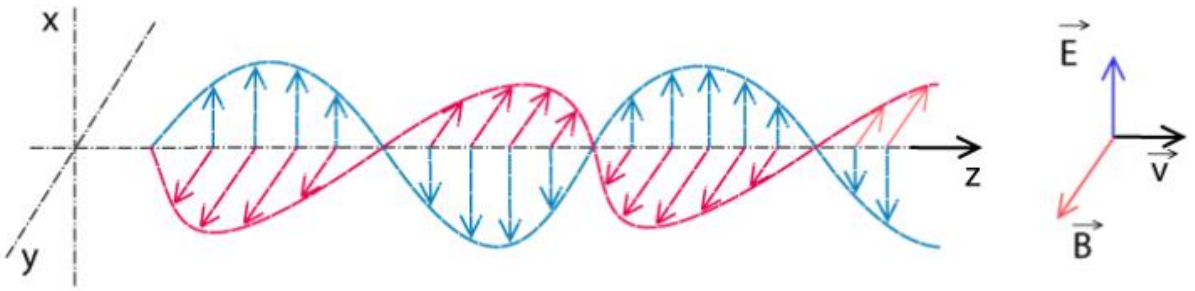
- The light behaves as a wave, categorized as one of the electromagnetic waves because it is made of electric and magnetic fields.
- Electromagnetic fields perpendicularly oscillate to the direction of wave travel and are perpendicular to each other.



$\vec{E}$ is the electric field intensity

$\vec{B}$ is the magnetic field density

Optical Spectrum



The electric field at position *z* at time *t*

$$E_x = E_o \cos(\omega t - kz + \phi_o)$$

E_o *is the amplitude of the wave*

K *is the propagation constant,* $k = \frac{2\pi}{\lambda}$

λ *is the wavelength*

ω *is the angular frequency*

ϕ_o *is the phase constant*

Basic optical equations

- The speed of light in the vacuum (c) is equal to the wavelength λ times the frequency ν , so that

$$c = \lambda\nu$$

- When light passes from one medium to another (say from air to medium), its frequency remains unchanged.

$$f = \frac{c}{\lambda_a} = \frac{v_m}{\lambda_m} \quad \Rightarrow \quad \frac{c}{v_m} = \frac{\lambda_a}{\lambda_m}$$

Basic optical equations

- The relationship between the *energy of a photon* and its frequency (or wavelength) is determined by the equation known as *Planck's Law*

$$E = hf = \frac{hc}{\lambda}$$

$$E(e.V) = \frac{1.2406}{\lambda\ (\mu m)}$$

where $\mathrm{h} = 6.625 \times 10^{-34}\ J.S.$ is the Planck's constant

$1\ \mathrm{e.V} = 1.6 \times 10^{-19}\ J$

Basic optical equations

Refractive Index

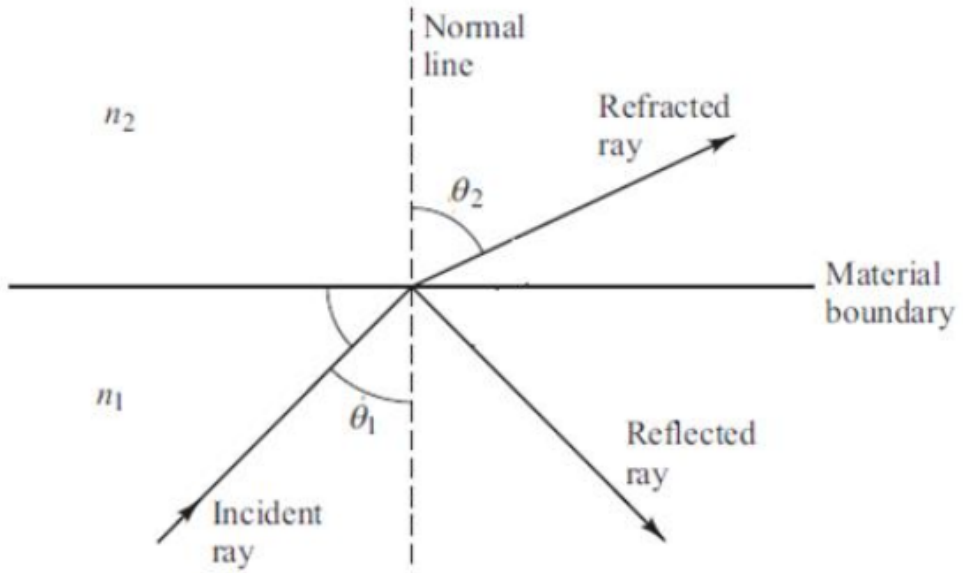
- It is a fundamental optical parameter of a material.
- In free space, a light wave travels at a speed $c = 3 \times 10^8$ m/s.
- Upon entering a dielectric or nonconducting medium, the wave now travels at a speed ***v***, which is characteristic of the material and is less than ***c*** so that

$$n = \frac{c}{v}$$

Basic optical equations

Refraction law (Snell's law)

- When a light ray pass through a boundary separating two different media, part of the ray is reflected back into the first medium and the remainder is bent (or refracted) as it enters the second material.



$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

6 - (IOC) & (PIC) & (OEIC)

6 - Integrated optical circuit (IOC)

- integrated optical circuit (IOC):

A circuit, or group of interconnected circuits, consisting of very small solid-state optical components on semiconductor or dielectric substrates.

Note: IOC components include light sources, optical filters, photodetectors.

7 - photonic integrated circuit (PIC)

- The photonic integrated circuit (PIC) is generally used when all the integrated components are photonic devices, e.g., lasers, detectors, amplifiers, modulators, and couplers.

8 - Optoelectric integrated circuit (OEIC)

- Technologies for integrating optoelectronic devices and electronic circuitry (still under development).

9 – Why optical Communications needed?

Transmission by Light: *why*?

- Growing demand for faster and more efficient communication systems
- Internet traffic is tripling each year
- It enables the provision of Ultra-high bandwidth to meet the growing demand
- Increased transmission length
- Improved performance
- etc.

Laser Communications

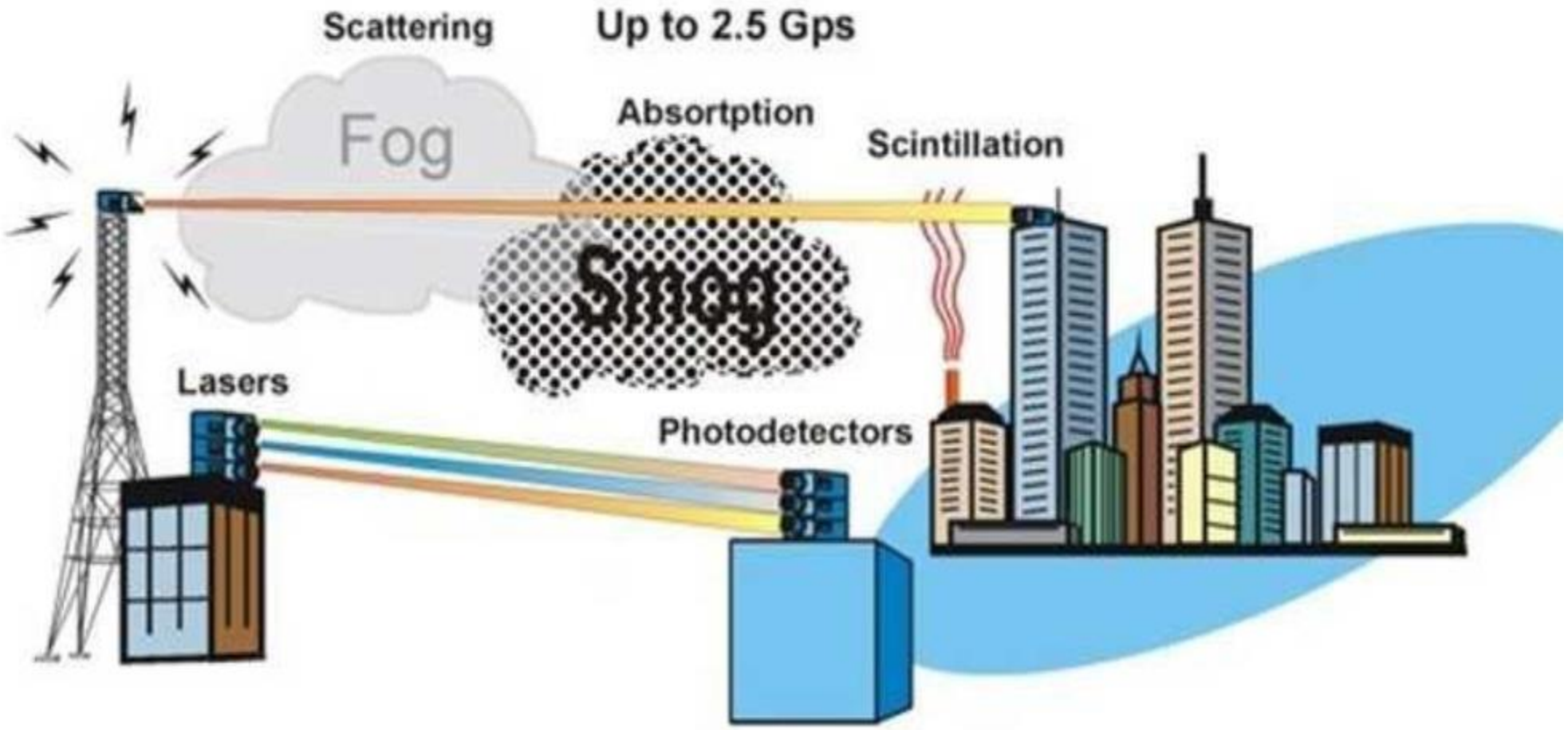
A **Laser** beam inside a **fiber** can carry up to 6 Tb/s or ≈ **100 million** telephone conversations simultaneously

Information revolution wouldn't have happened without Optical Communication Techniques

What will be the substitute for copper when dealing with LIGHT ?

"Air" as a TRANSPARENT medium "WAS" the first choice.. **BUT** became unsuitable for Reliable Communication Links.... **Why**?

Vulnerability to Environmental Conditions



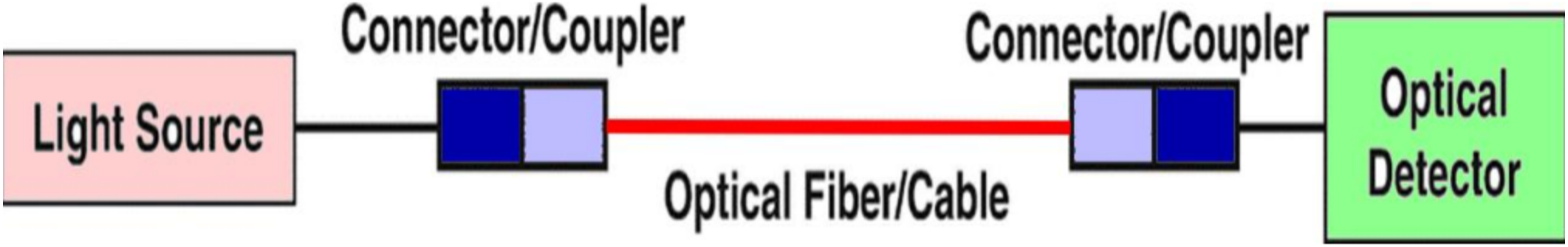
Optical Fiber

the backbone of the modern communication networks

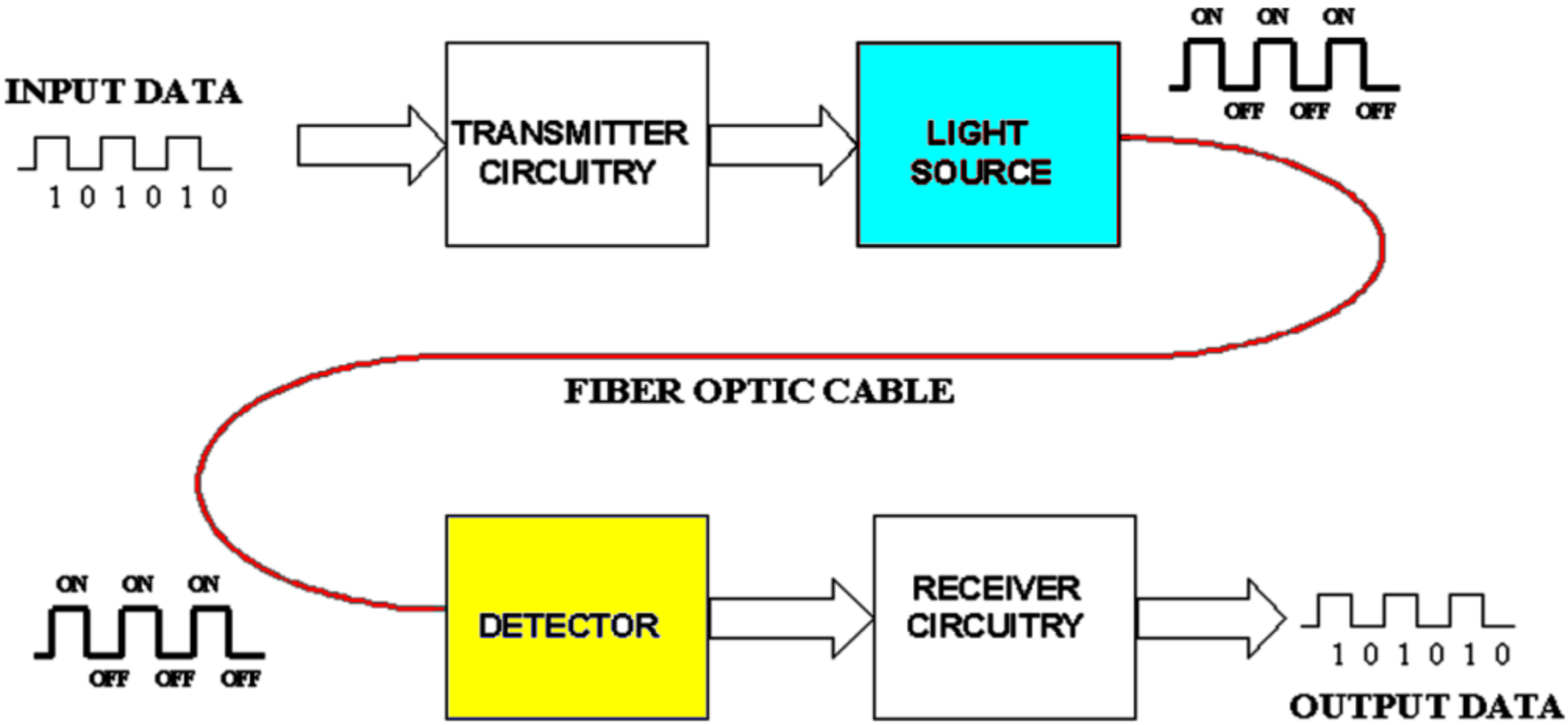
The Optical Fiber Carries:

- Almost all long distance phone calls
- Most Internet traffic (Dial-up, DSL or Cable)
- Most Television channels (Cable or DSL)

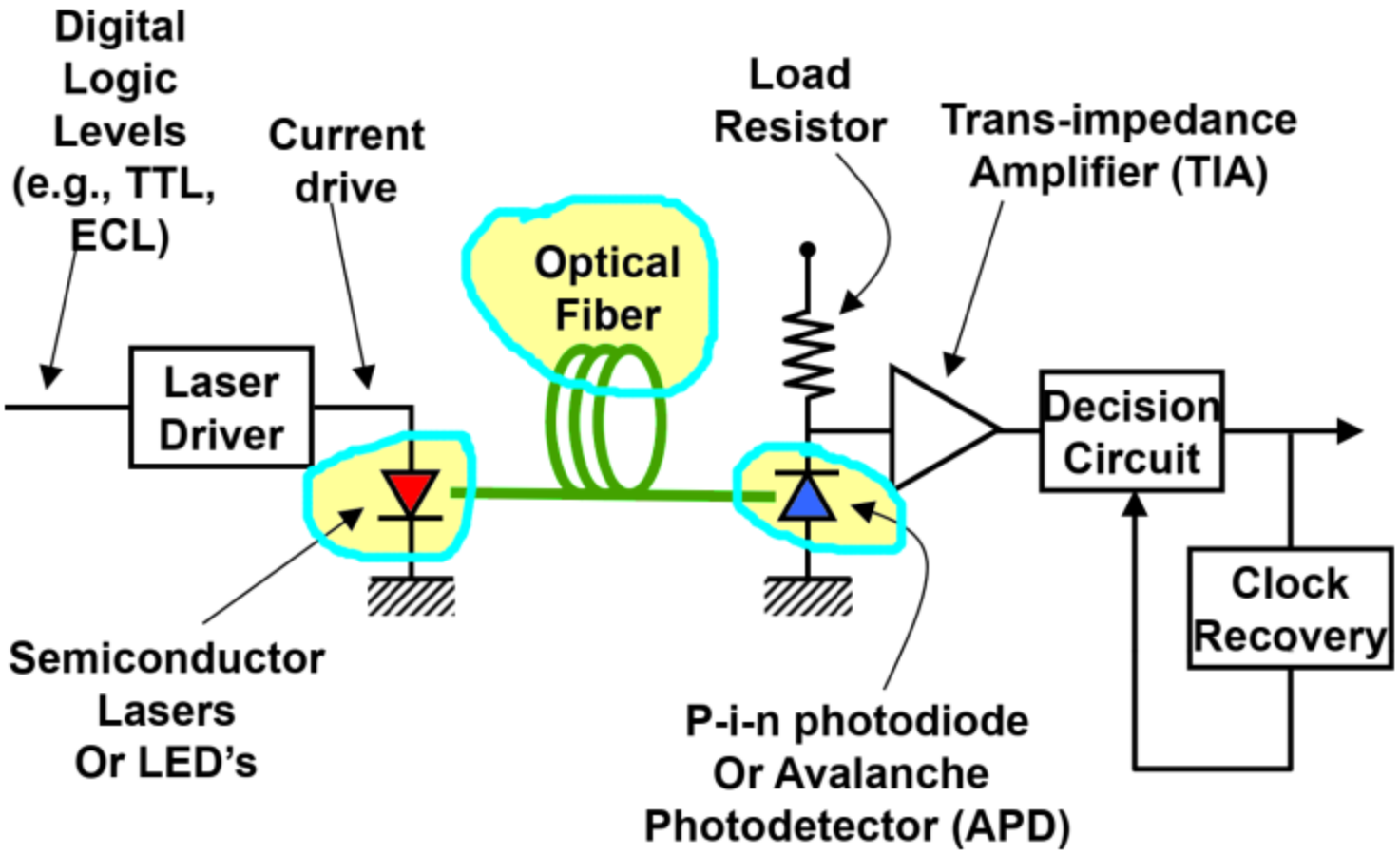
Basic Elements of an Optical Communication Link



A simple System



Typical Fiber Optic Links



Crucial Parameters of an Optical Fiber

Attenuation

Dispersion

overlapping

Thank you for your attention