ANKARA UNIVERSITY
ELECTRICAL AND ELECTRONICS ENGINEERING

OPTOELECTRONICS LABORATORY

LAB MANUAL

2013

CONTENT

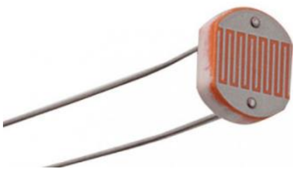
GENERAL LAB REPORT COMMENTS

1. The lab report should be a concise report of the important results in the lab.
2. It should be a complete record of your work in the lab: theoretical background, calculations and anticipated performance, empirical verification, and discussion of the results.
3. While the report does not need to be as detailed as the lab notebook, it should "stand alone" - that is, it should be sufficiently self-contained so that it can be read and understood without reference to the lab handout.
4. The format used here is straightforward: introduction, circuit description, measurement results, discussion, conclusions. This format isn't mandatory; feel free to modify it for a particular lab if the presentation is clearer.

List of Required Materials

1. Various 5mm Leds with green, red, yellow, blue, white color (two each)

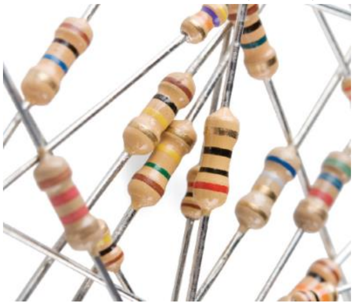
2. LDR sensor (light dependent resistor)



3. Two Infrared 5mm leds (their wavelengths are 850 nm and 940 nm)

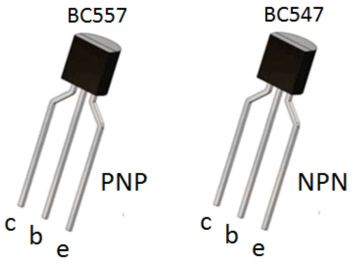
4. Photodetector and phototransistor (two each)

5. Various resistors, 100, 270, 470, 1k, 2k, 4,7k, 10k, 50k, 100k, 1M (two each)



6. Optocoupler (4N25)

7. Transistor BC547,BC557 (two each)



8. Trimmer Potentiometer (trimpot 50k, 10k)

INTRODUCTION

Optoelectronics is the study and application of electronic devices that interact with light. In this context, ***light*** often includes invisible forms of radiation such as gamma rays, X-rays, ultraviolet and infrared. Optoelectronic devices are electrical-to-optical or optical-to-electrical transducers, or instruments that use such devices in their operation. Optoelectronics is based on the quantum mechanical effects of light on semiconducting materials, sometimes in the presence of electric fields.

Optoelectronic devices can be classified according to the physical phenomena used in various devices as shown in Fig. 1. Combination of both electrical-to-optical/optical-to-electrical devices in a system can be found in many applications such as optocouple, fiber optical communications etc.

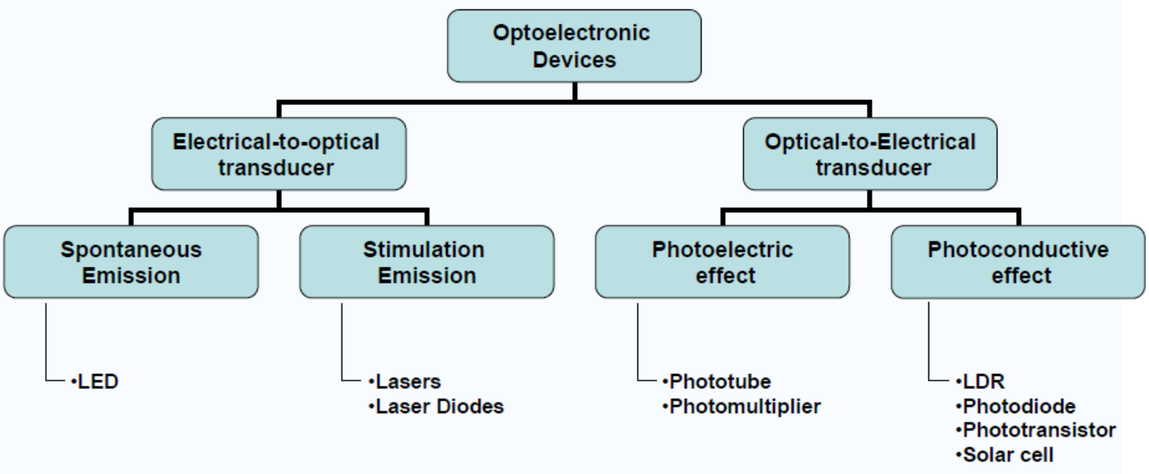


Fig. 1 Classification of optoelectronic devices with examples.

Photoconductive Effect

The photoconductive effect is an optical and electrical phenomena, in which the electrical conductivity of a semiconductor material increases when exposure to light or an electromagnetic radiation. Consider a semiconductor material is under an optical excitation as shown in Fig. 2.

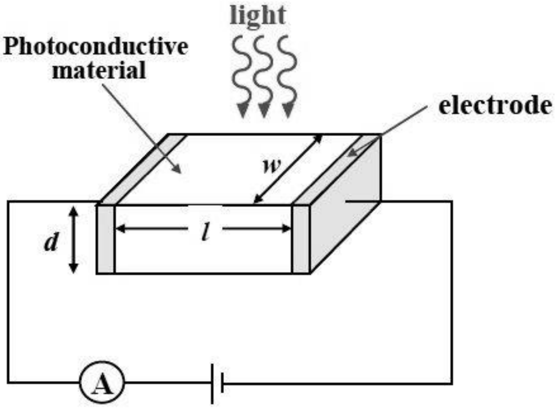


Fig. 2 A semiconductor is illuminated with light of wavelength λ

If the photon energy is greater than the energy gap, Eg of the semiconductor, Incident photons become absorbed in the semiconductor, and the electron hole pairs (EHP) will be generated. Here, the relation between photon energy and wavelength, λ is

$$E = hc/\lambda = 1.24/\lambda \text{ (in nm)} \tag{1}$$

where,

E is the electrical conductivity at thermal equilibrium,

h is the Plank's constant = 6.63×10^{-34} J s

c is the speed of light in free space ~ 3×10^{8} m/s

λ and p are the electron and hole concentration at normal condition, respectively.

Δn and Δp are the electron and hole concentration due to the photogeneration, respectively.

Therefore, the considerable absorption will occur under the condition $Eg > E$. The band gap energies of some common semiconductor are given here, e.g. Si ~ 1.1 eV, GaAs ~ 1.43 eV, and CdS ~ 2.4 eV. The generation of EHP by the optical excitation, thus increases the conductivity of the semiconductor as follows

$$\sigma + \Delta\sigma = (n + \Delta n)q\mu_n + (p + \Delta p)q\mu_p \tag{2}$$

where σ is the electrical conductivity at thermal equilibrium

$\Delta\sigma$ is the increment of conductivity due to the optical excitation,

q is the electron charge = 1.6 x 10-19 Coulomb,

n and p are the electron and hole concentration at normal condition, respectively

Δn and Δp are the electron and hole concentration due to the photogeneration, respectively

μ_n and μ_p are the mobility of electron and hole, respectively.

Radiative Recombination: Spontaneous Emission

In physics, it is well known that when an atom, molecule or nucleus in an excited state drops to a lower-energy state**,** this results in the creation of a photon. In case of semiconductor, the electrons in the conduction band may make transitions to the valence band (i.e. recombine with holes in the valence band) as seen in Fig 3. . Energy lost by an electron in making transition is given up as a photon. In a device, there are many ways by which electrical energy can be used to generate photon. For example, in LEDs an electric current causes the injection of minority carriers (electron or hole) into regions of the crystal where there are recombine with majority carriers (electron or hole), resulting in the emission of recombination radiation.

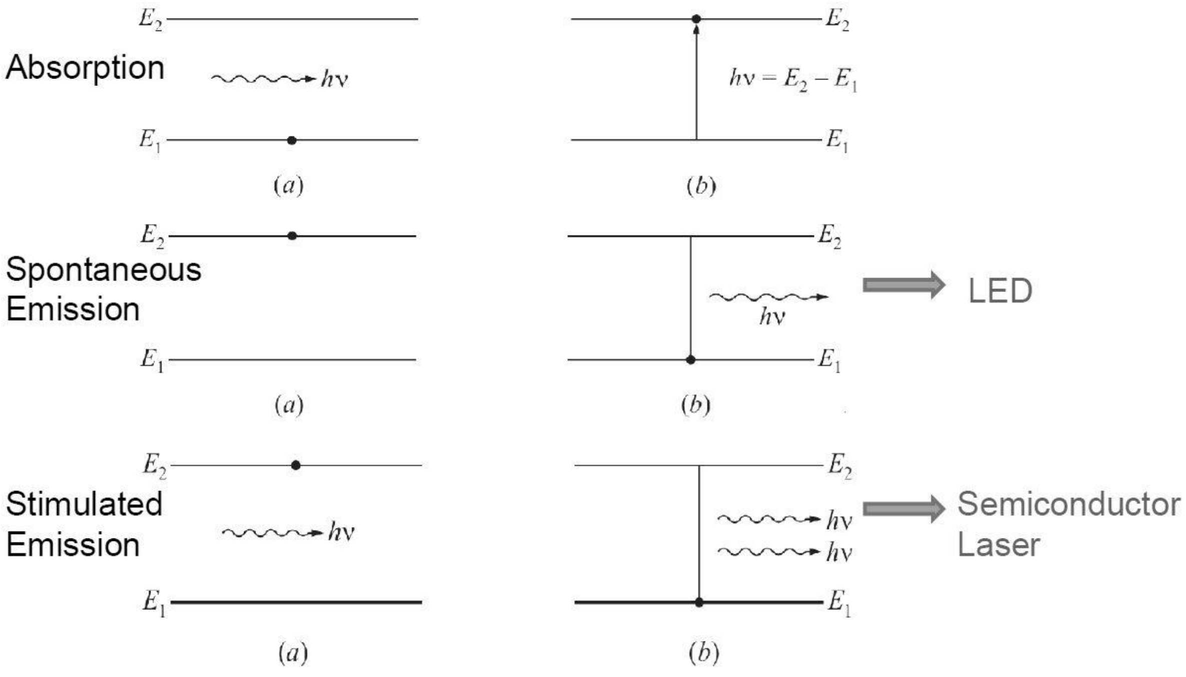


Fig 3. Basic electronic transition's. Where (a) is initial state (b) is final state.

Electromagnetic Spectrum:

The electromagnetic spectrum is a continuum of all electromagnetic waves arranged according to frequency and wavelength. The sun, earth, and other bodies radiate electromagnetic energy of varying wavelengths. Electromagnetic energy passes through space at the speed of light in the form of sinusoidal waves.

The electromagnetic spectrum extends from below the low frequencies used for modern radio communication to gamma radiation at the short-wavelength (high-frequency) end, thereby covering wavelengths from thousands of kilometers down to a fraction of the size of an atom. The limit for long wavelengths is the size of the universe itself, while it is thought that the short wavelength limit is in the vicinity of the Planck length, although in principle the spectrum is infinite and continuous.

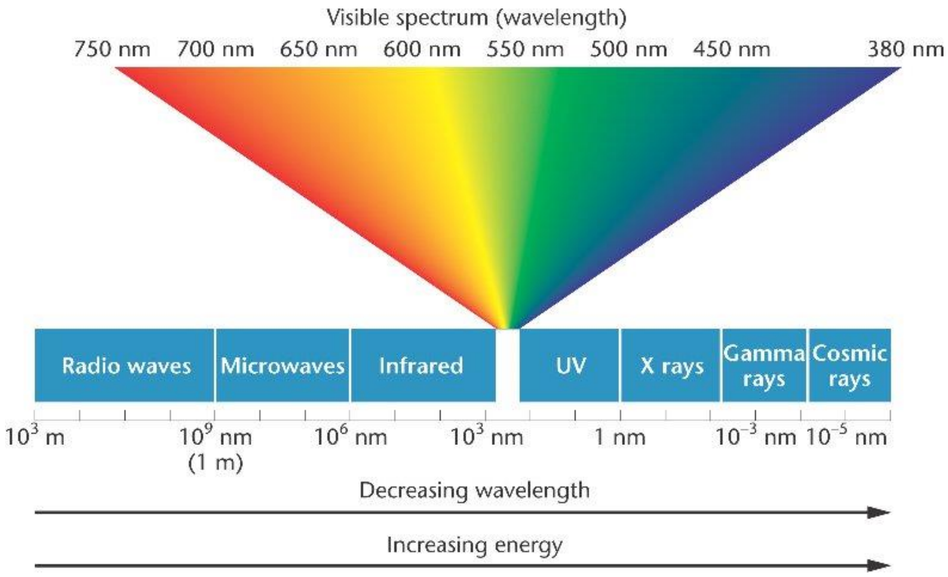


Fig 4. Electromagnetic Spectrum

Electromagnetic waves are typically described by any of the following three physical properties: the frequency f, wavelength λ, or photon energy E, related by following equations,

$$f=c/\lambda, \quad f=E/H, \qquad E=hc/\lambda \tag{3}$$

where, c = 299,792,458 m/s is the speed of light in vacuum and

h = 6.62606896(33)×10^{-34} J s = 4.13566733(10)×10^{-15} eV s is Planck's constant.

REFERENCES

1. Course notes of Chulalongkorn University

2. http://en.wikipedia.org

3. V.P Seth, Physics for Engineers , New Age International Inc., 2011.]