Fundamentals of Electronics Devices

Unit-2

Lecture-3

Luminescence

- When electron-hole pairs are generated in a semiconductor, or when carriers are excited into higher impurity levels from which they fall to their equilibrium states, light can be given off by the material.
- Many of the semiconductors are well suited for light emission, particularly the compound semiconductors with direct band gaps.

Introduction

- The general property of light emission is called *luminescence.*
- This overall category can be subdivided according to the excitation mechanism:

  If carriers are excited by photon absorption, the radiation resulting from the recombination of the excited carriers is called *photoluminescence;*

- If the excited carriers are created by high-energy electron bombardment of the material, the mechanism is called *cathodoluminescence;*
- If the excitation occurs by the introduction of current into the sample, the resulting luminescence is called *electroluminescence.*
- Other types of excitation are possible, but these are the most important for devices.

Photoluminescence

- The simplest example of light emission from a semiconductor occurs for direct excitation and recombination of an EHP.
- If the recombination occurs directly rather than via a defect level, band gap light is given off in the process.
- For steady state excitation, the recombination of EHPs occurs at the same rate at the generation, and one photon is emitted for each photon absorbed.

Exercise

- A 0.45 μm thick sample of GaAs is illuminated with monochromatic light of $h\nu$ = 2 eV. The absorption coefficient α is 5 X 10^4 cm^{-i}. The power incident on the sample is 10 mW.

(a) Find the total energy absorbed by the sample per second (J/s).

(b) Find the rate of excess thermal energy given up by the electrons to the lattice before recombination (J/s).

Electroluminescence

- There are many ways by which electrical energy can be used to generate photon emission in a solid.
- In LEDs an electric current causes the injection of minority carriers into regions of the crystal where they can recombine with majority carriers, resulting in the emission of recombination radiation.

- The first electroluminescent effect to be observed was the emission of photons by certain phosphors in an alternating electric field (the Destriau effect).
- In this device, a phosphor powder such as ZnS is held in a binder material (often a plastic) of a high dielectric constant.
- When an a-c electric field is applied, light is given off by the phosphor.