Lecture 16

Reading Material

Reading:

Chapter 8 Solymar and Walsh

HW due Thurs March 11 at TA recitation

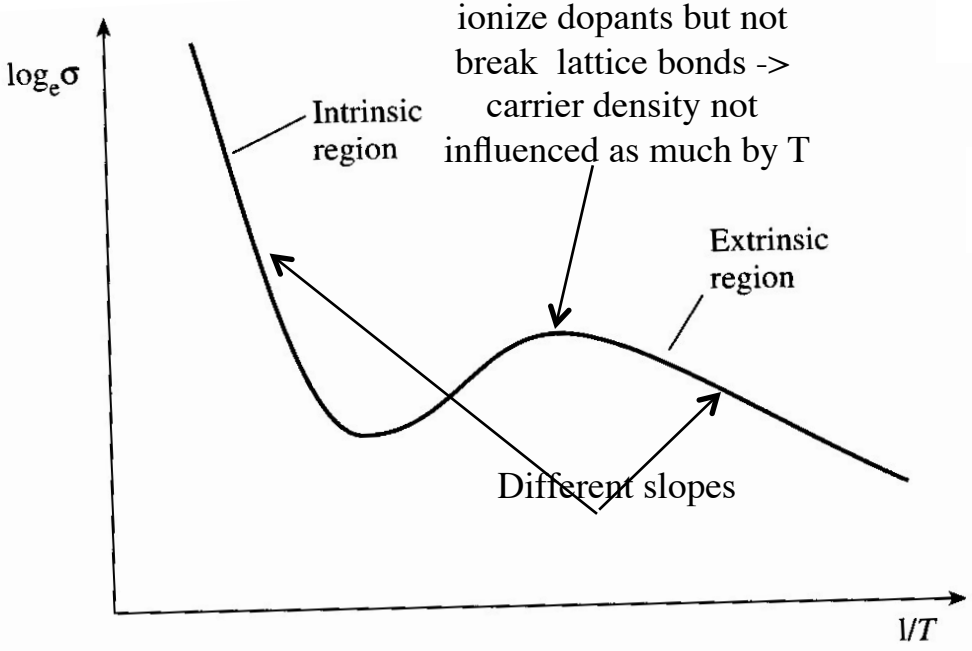
S&W

Chapter 8

Problems 8.9, 8.10, 8.14, 8.16, 8.19

Measurement of Energy Gap

- Change in conductivity as a function of temperature



$$N_e = N_h = N_i = \text{constant} \times T^{3/2} \exp\left(\frac{-E_g}{2kT}\right)$$

$$\sigma = \text{constant} \times e(\mu_e + \mu_h) T^{3/2} \exp\left(-\frac{E_g}{2kT}\right)$$

$$= \sigma_0 \exp\left(-\frac{E_g}{2kT}\right).$$

Fig. 8.17
Typical log conductivity–reciprocal temperature curve for an extrinsic semiconductor.

Measurement of Energy Gap

- Using Optical Transmission
  - If wavelength is small photons will excite breaking of bonds to move electrons into conduction band
  - Most of the photons at high frequencies are absorbed and the optical loss is high
  - At longer wavelengths when absorption is low due to decreased photon energy to break bonds, material (if thin enough) will become optically transparent.

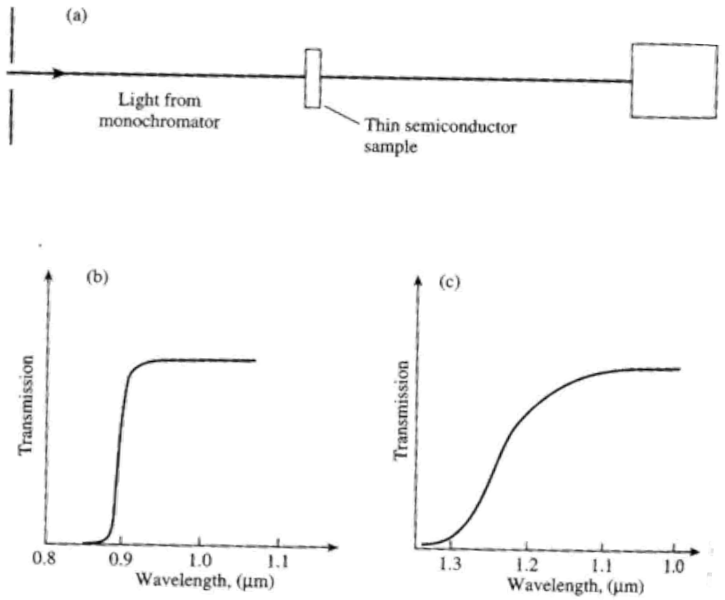


Fig. 8.18
(a) General arrangement of an optical transmission measurement and the result for (b) GaAs and (c) Si.

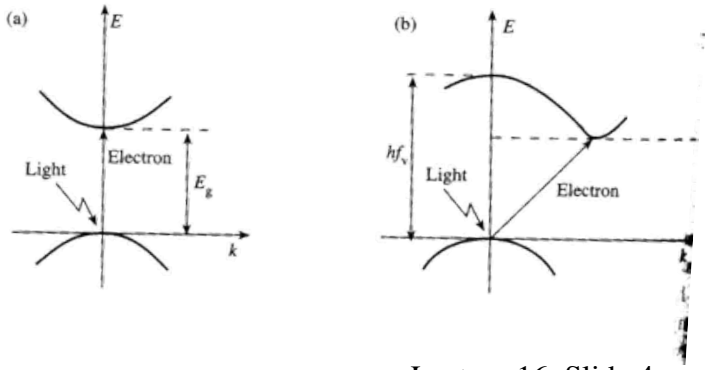
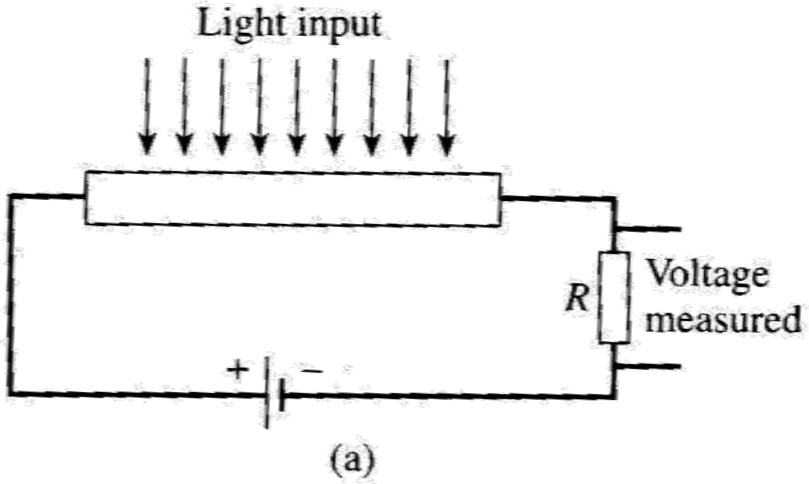


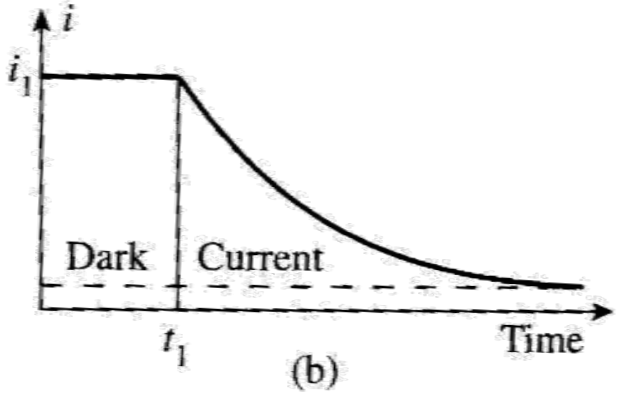
Fig. 8.19
Photon absorption by (a) a direct and (b) an indirect-gap semiconductor.

Measurement of Carrier Lifetime

- Photoconductive switching
  - Apply light beam them remove, measure current as function of time
  - With light beam, photons are absorbed creating electron hole pairs, and conductivity increases
  - Use circuit to measure voltage across load resistor which is a measure of current passing through semiconductor being measured
  - As carriers recombine, conductance will decrease due to decrease in carriers. The current through and hence voltage resistor will drop with a time constant related to the carrier lifetime



(a)



(b)

Types of Growth

- Crystal Growth
  - First developed in 1950s to grow semiconductor crystals
  - Material is purified then melted in a crucible
  - As crucible is cooled down single crystal forms with purest material at bottom and less pure as a gradient of purity moving up the cooled semiconductor
  - Floating Zone method was developed for small silicon crystals that eliminated the crucible and moved to a crystal rotated by a chuck surrounded by a heating coil
- Epitaxial
  - Process of growing and refining single crystals using a planar method.
  - Vapour phase epitaxial growth is used by flowing the correct vapours into a tube furnace to make a chemical reaction that produces pure silicon
  - Liquid phase epitaxial growth is used mostly for compound semiconductors. A substrate semiconductor is place in a boat and immersed in molten semiconductor and the time and temperature are used to regulate the growth thickness of the new layer
  - Molecular beam epitaxy (MBE) is a technique that uses target of different materials, with high energy sources that ablate the targets and deposit the atoms from each target in a controlled manner onto a substrate. Atomic thick layers can be deposited and using a chamber with different sources allow different layers and compound layers to be grown.

Types of Growth

- Epitaxial
  - MOCVD – Metal organic chemical vapour deposition: not as easy to control atomic dimension growth but more commercially friendly.
  - Can be used on wafers with large areas
  - Typically done at near atmospheric pressure
  - Used for most communications lasers, LEDs, although many lasers are also grown using MBE