

Radiation Detection and engineering of radiation detectors

Part 3

Semiconductor detector

Definition

- **A semiconductor detector :**
Is a device that uses a semiconductor material (usually silicon or germanium) to measure the effect of incident charged particles or photons.
- **Semiconductor detectors** find broad application for radiation protection, gamma and X-ray spectrometry, and as particle detectors.

Detection mechanism

- In semiconductor detectors, ionizing radiation is measured by the number of charge carriers set free in the semiconductor material which is arranged between two electrodes, by the radiation.
- Ionizing radiation produces **free electrons and holes**.
- **The number of electron-hole pairs is proportional to the energy of the radiation to the semiconductor.**

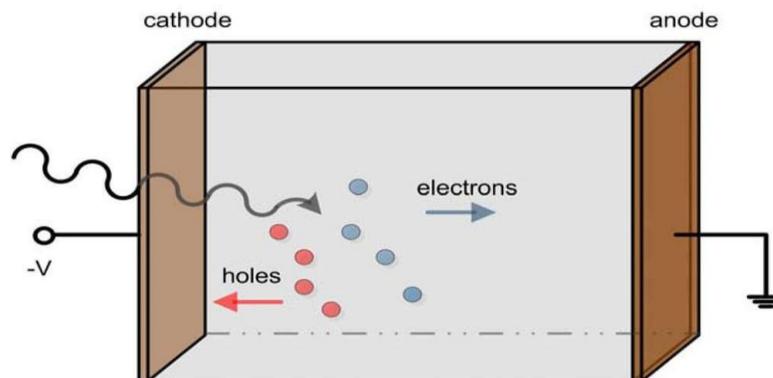


Figure (1): Semiconductor Detector

- As a result, a number of electrons are transferred from the valence band to the conduction band, and an equal number of holes are created in the valence band.

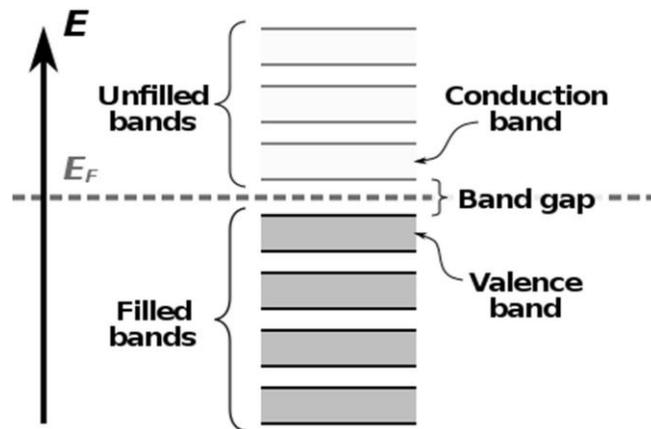


Figure (2): The conduction and valence bands in the semiconductor material

- **Under the influence of an electric field, electrons and holes travel to the electrodes, where they result in a pulse that can be measured in an outer circuit.**
- The amount of energy required to create an electron-hole pair is independent of the energy of the incident radiation.
- **Measuring the number of electron-hole pairs allows the intensity of the incident radiation to be determined.**

Comparison between semiconductor and gas detectors

- **The energy required to produce electron-hole-pairs is very low** compared to **the energy required to produce paired ions** in a gas detector.
- Consequently, **in semiconductor detectors the statistical variation of the pulse height** is smaller and the **energy resolution is higher**.
- Compared with gaseous ionization detectors, **the density of a semiconductor detector is very high**, and charged particles of high energy can give off their energy **in a semiconductor of relatively small dimensions**.

Table – 1 : Comparison between semiconductor and gaseous detectors (مهم)

	semiconductor	gaseous detectors
Energy required to produce electron-hole-pairs	Very low	medium
Statistical variation of the pulse height	small	medium
Energy resolution	high	medium
Density	Very high	low
Dimensions	small	large

Detector types

1. Silicon detectors

- The silicon detectors cannot be thicker than a few millimeters.
- Silicon detectors have a much higher resolution in tracking charged particles than older technologies.
- The drawback is that silicon detectors are :
 - 1 - much more expensive than these older technologies . require sophisticated cooling to reduce leakage currents (noise source)
 - 2 They also suffer degradation over time from radiation.

2. Diamond detectors

- Diamond detectors have many similarities with silicon detectors.
- But are expected to offer significant advantages, in particular a high radiation hardness and very low drift currents.
- At present they are much more expensive and more difficult to manufacture.

3. Germanium detectors

- Germanium detectors are mostly used for gamma spectroscopy in nuclear physics, as well as x-ray spectroscopy.
- Germanium detector can have a sensitive thickness of centimeters, and therefore can be used as a total absorption detector for gamma rays up to few MeV.
- The major drawback of germanium detectors is that they must be cooled to liquid nitrogen temperatures to produce spectroscopic data.

