Introduction to Measurement Systems: Diodes currents *vs* voltage curves

LA-CoNGA physics

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1 Background

1.1 PN junction diodes

The PN junction diode is a device which is commonly used in circuit applications such as rectification where current is allowed to flow in only one direction. When the diode is fabricated in silicon, the forward voltage drop is typically $0.7V$ and the V_D *vs* I_D characteristic relating diode voltage and current can be described by an exponential relationship:

$$I_D = I_S \left[exp\left(\frac{eV_D}{nKT} \right) - 1 \right] \tag{1}$$

where I_S and n are scale factors, and kT/e ($25.4mV$ at room temperature) is the so called thermal voltage V_T.

1.2 Zener diodes

A Zener diode is similar in construction and operation to an ordinary diode. Unlike a conventional diode where the intended use is to prevent current in the reverse direction, a zener diode is mostly used in the reverse region above the breakdown voltage.

1.3 Schottky diodes

The normal current *vs* voltage (I/V) curve of a Schottky barrier diode resembles that of a PN junction diode with the following exceptions:

- The reverse breakdown voltage of a Schottky barrier diode is lower and the reverse leakage current higher than those of a PN junction diode made using the same resistivity semiconductor material.

- The forward voltage at a specific forward current is also lower for a Schottky barrier diode than for a PN junction diode. For example, at $2mA$ forward bias current a low barrier silicon Schottky diode will have a forward voltage of ≈ 0.3 volts while a silicon PN junction diode will have a voltage ≈ 0.7 volts. This lower forward voltage drop can cut the power dissipated in the diode by more than one half. This power savings can be very significant when the diodes need to carry large forward currents. The current vs. voltage (I/V) relationship for a Schottky barrier diode is given by the following equation known as the Richardson equation. The primary difference from the conventional diode equation is in I_S with the addition of the modified Richardson constant A^*.

$$I_S = AA^*T^2 exp\left(-\frac{ef_B}{KT}\right) \tag{2}$$

  Where:

  - A, junction area
  - A^*, modified Richardson constant (value varies by material and dopant) $= 110A/(^oK^2 - cm2)$ for $n - type$ Si
  - f_B, barrier height in volts

2 Activities

1. Using LTSpice generate IV curves for all three diodes described above
2. Describe one applications of each diode