The Fermi Function Lesson

Using The Fermi Function

The Fermi function is a probability distribution function. It can only be used under equilibrium conditions. The Fermi function determines the probability that an energy state (E) is filled with an electron when the material we are working with is under equilibrium conditions. The Fermi level (E_F) helps determine carrier distributions. To a first approximation, all the energy states above the Fermi level have a low probability of being filled with electrons and all the energy states below the Fermi level have a high probability of being filled with electrons. For an electronic state with energy the same as E_F, the probability of that state being filled is 1/2, or 50%.

Some of the properties of the Fermi function are:

The probability an energy state is occupied: $$f(E) = \frac{1}{1 + e^{(E-E_F)/kT}}$$

The probability an energy state is empty: $1 - f(E)$

The Fermi function at $E = E_F$: $f(E_F) = 1/2$

The Fermi function is simply a mathematical function and has no units: $0 < f(E) < 1$

In a band diagram, the position of the Fermi level determines which carrier dominates. If the semiconductor contains more electrons than holes, *n*-type material, the Fermi level is positioned above mid gap. If holes are more abundant than electrons, *p*-type material, E_F is positioned below mid gap. When the electron and hole concentrations are approximately equal, intrinsic material, E_F is positioned at mid gap. The Fermi function, or level, also varies with temperature and carrier concentration.