

## Lab Prep Diode Lab

1. Diode is a non-linear component. Current voltage relation is non-linear. We call such a device non-Ohmic. The I-V relation is described by:

$$I = I_o \left( e^{eV/(nk_B T)} - 1 \right)$$

$I_o$  and  $n$  are device constants.  $I_o$  is called the leakage current and is normally very small, i.e. on the order of  $1E-8$  ampere. The  $n$  is a geometrical constant somewhere between 1 and 2.

Compare this I-V relation to the I-V relation of a resistor which is linear. A device with a linear I-V relation is called an Ohmic device.

Note that for such I-V relation the current depends on the sign of the voltage. For negative voltages the current is more or less constant and equal to  $-I_o$ .  $k_B$  is the Boltzmann constant and  $T$  is the temperature in Kelvin.

Draw the I-V characteristic on the black-board, emphasize that for positive voltages the -1 term can be neglected and for negative voltages the exponential term can be neglected. Emphasize that an exponential function goes more and more rapidly for larger  $x$  values: i.e. goes faster than a polynomial function for positive  $x$  value.

Then discuss the rectifying properties. Explain to the students that a diode is basically a one way valve, that will only let current flow in one direction.

2. The diode gets his rectifying properties from the fact that it is made of semiconductor material. A semiconductor in pure form is a very poor conductor and behaves similarly as an insulator. Semiconductor material however can be made conductive by replacing some of the silicon atoms with impurities. In general two different types of semiconductors can be made: n-type semiconductors and p-type semiconductors. N-type semiconductors have free electrons: negative charges. So if one applies a voltage to an n-type semiconductor, the free electrons can move freely through the semiconductor and form the current. P-type semiconductors have free holes: this are positive charges. A hole is the absence of an electron. So the best way to visualize a hole is to think of the bobcat stadium that is almost completely sold out. However there are still a couple of empty seats in the stadium. People can move from seat to seat. If all people try to move as far to the right as possible (we only allow one person on one seat) the empty seat will move to the left. A hole in a semiconductor material is something similar. It behaves like a positive charge and even has an inertial mass a little lower or a little higher than the free electron rest mass. A diode is made by n-type and p-type semiconductor material. The non-linear rectifying properties of a diode originate from the non-linear I-V characteristic of an interface between a p-type and n-type semiconductor. You will learn more about this in upper division classes such as modern physics, applied electronics, and solid state physics.

