Light Emitting Diodes (LEDs)

Overview

This module is intended to introduce students to the use of the periodic table to customize the properties of materials. The properties of light emitting diodes (LEDs) are controlled by chemistry. LEDs are increasingly used in a variety of lighting venues, including traffic lights, animated billboard displays, vehicle tail lights and dashboard lights. They are comprised of semiconductors whose chemical composition can be tuned using periodic properties, such as isoelectronic principles, electronegativity, and atomic radius. Variations in these properties can be used to control the color of light the semiconductors emit. Solid solutions, in which chemically similar elements like phosphorus and arsenic are substituted for one another in a crystal structure, enable the to light emitted by the semiconductor to be tuned over various regions of the electromagnetic spectrum.

Investigations and demonstrations in this module explore the structures of semiconductors that are key to LED technology, using the ICE Solid State Model Kit. These structures are correlated with chemical composition, the diffraction of light emitted by LEDs of different colors, and the voltage needed to activate them, all of which reflect the bonding trends in these solids. A simple model for understanding these trends based on bonds can be presented, as well as a more sophisticated model based on bands, which comprise combinations of atomic orbitals. A demonstration of these structural and bonding concepts can be shown by "eyeball spectroscopy," in which the colors of some LEDs can be reversibly altered by exposing them to a cold environment like dry ice/acetone or liquid nitrogen.

The rapid movement of this technology is underscored by presenting the recent development of the long-sought-after blue LED, which was obtained by combining gallium with nitrogen. This development makes it possible to use color mixing to obtain all colors of the visible spectrum, along with white light. Technological implications of the availability of this shorter wavelength light include new kinds of display devices. Semiconductor diodes can also be used as lasers and are often employed as presentation pointers. Blue diode lasers, when they become available, offer the opportunity to create CDs with greatly enhanced storage capacity.