

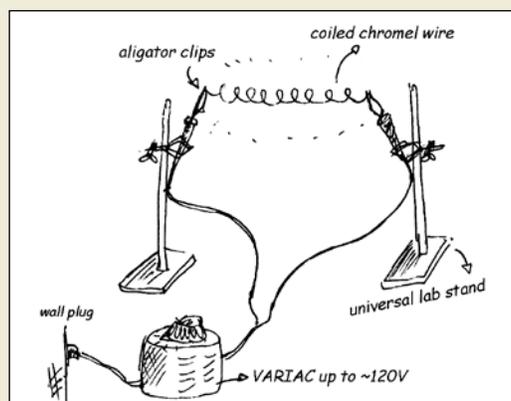
Smart Materials: The light bulb

The light bulb technology is simple but a great advancement to society, and of course materials played a major role in its development. To show this, build an incandescent light in the classroom by coiling a metal wire and powering with a controllable AC power supply. Place the coiled wire (coil size can vary, but $\frac{1}{4}$ inch coils works great) held by lab supports as shown in the figure. The metal used should withstand high enough temperatures so that a bright light can be seen at high voltages without it falling apart. A chromel alloy, used in thermocouples, is very suitable. Turn on the power supply and increase the voltage. The wire will start glowing beautifully, so keep increasing the voltage until it fails (after an intense glow). This will happen because of both oxidation of the wire and because we reach its melting point. Then you can explain why light bulbs have an inert gas inside (to minimize oxidation) and why the filaments are made of tungsten (because of its high melting point). Note that the wire can stretch on its weight before failure due to the high temperatures.

Have a student carefully feel the heat coming off the wire. You can explain that this is wasted energy and link this to the better new technologies, such as LEDs. Briefly explain that light and heat are being generated because the metal is not a perfect conductor. The electrons 'hit' the structure and defects when they are transferred from one pole to the other, causing heating.

Attention! This is a simple but dangerous experiment. Depending on the size of the coil, high power may be needed (and of course, bigger is more fun). The wire gets very hot, so perform the experiment yourself on a table in front of the class and avoid having students come too close. Have a fire extinguisher close by.

What do they learn? Light can be generated by the relatively limited conductivity of metals, but metal filaments also generate heat and are thus inefficient. Materials oxidize and melt, and materials selection and proper operating conditions, i.e., tungsten and inert atmosphere, were required to enable this technology.



What do you need?

Chromel alloy wires long enough to be coiled, an AC power supply (Variac) with high out put power (~ 10 A), alligator connectors and cords to wire the setup, two universal lab stands, small fire extinguisher. Note 1: you will need to short the fuse in the Variac to allow more current to flow; use an aluminum/copper wire to replace it, but be careful—too much current may burn out the power supply. Note 2: for an impressive demonstration, use galvanized steel wires instead of chromel. The zinc will rapidly oxidize, creating beautiful "fireworks" on the wire surface!