CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)
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Project Number
S1919

Project Title
The Physics of Operating Compact Fluorescent Lamps

Abstract

Objectives/Goals
The objective of my science project was to study the physics of the operation of a compact fluorescent lamp (CFL); specifically why the light output of a CFL is affected by temperature and why the light output is non-uniform along its length. My hypothesis was that the light output and non-uniformity are the result of non-uniform Hg vapor pressure due to temperature variations along the length of the lamp.

Methods/Materials
A two inch diameter, eight inch long CFL was used to test my hypothesis. The lamp was detached from its ballast electronics and mounted separately in an isothermal Styrofoam enclosure to remove any temperature effects of the ballast electronics from the performance of the Hg-filled lamp. A solar cell mounted to the wall of the enclosure was used to measure the light output of the lamp. The temperature of the lamp was measured at three locations along its length; at the base, the midpoint, and tip. Correlations were made between lamp temperature, lamp light output, and electrical power.

Results
1. The light output of a CFL increases to a maximum of 50% above the initial turn-on light level and then decreases by 20% below the maximum light level at a steady state.
2. The lamp temperature continuously increases until steady state is reached. At equilibrium, there is a 60 °C temperature gradient between the base and tip.
3. The increase in light output before the maximum is reached, correlates with increased Hg vapor pressure that follows the Clausius-Clapeyron equation.
4. The decrease in light output after the maximum is reached, correlates with UV radiation trapping by Hg vapor.

Conclusions/Discussion
A compact fluorescent lamp does not operate at its maximum light output. The non-uniform temperature distribution along the length of a CFL is due in part of a hot filament at the base of the lamp. The Clausius-Clapeyron equation accounts for the initial increase in light output after lamp turn on, while mercury radiation trapping is responsible for the light output maximum and subsequent decrease.

Summary Statement
The operation and light output of a compact fluorescent lamp is strongly influenced by the properties of mercury vapor.

Help Received
My father greatly helped with the general assembly of the entire project, acquiring parts, and in data measurements. The CSUN Oviatt Library staff allowed me to use their databases and helped me find a number of articles from which I got ideas for my project.