CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
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Project Number
J1121

Project Title
An Analysis of Bismuth-Telluride Based Peltier Devices

Abstract

Objectives/Goals
The purpose of my science project was to understand the materials science (including structure, electrical and heat-flow properties) of peltier devices and to design a small portable peltier based refrigerator in order to test, gather data and analyze the efficiency, heat flows, and other properties of these semiconductor-based static devices.

Methods/Materials
2 peltier coolers, 10 ft. of silver insulation, Infrared thermometer, 1-1# fan, 1-3# fan, Heat sink, X-Acto blade, 1-12-volt power supply, Silver tape, 8x8x12# cardboard box, Anderson Power Pole connectors, Packing Tape, Electronic Temperature Sensor. Using my test apparatus, I tested the internal resistance of my peltier device. Then, using a calibrated resistive heater applied to the heat sink, I reproduced the Seebeck Effect to determine the thermal conduction through the peltier device. Using a multimeter, I conducted a number of experiments to determine the efficiency and coefficient of performance for the Bismuth-Telluride (Bi2Te3) based peltier thermoelectric cooler. I also calculated as many of the heat flows as possible in my test system.

Results
The low internal resistance of the Bismuth-Telluride material results in high current flows that limit the efficiency of these devices, partly due to resistive heating. My measured efficiency approached 18% - about half that of a traditional compressor based refrigeration unit. However, analysis of the heat flows through the test system showed that the Bismuth-Telluride material in my peltier device had remarkable heat pumping properties for its size, but its construction and thermal conductivity limited its overall efficiency.

Conclusions/Discussion
This experiment showed how the unique crystalline properties of Bismuth-Telluride can exhibit a very strong peltier effect for use in many refrigeration applications. Future improvements that minimize resistive heating and thermal conduction could dramatically increase efficiency and applications for these devices and would allow the size of the peltier coolers to be increased as well.

Summary Statement
The goal of this project was to understand and test the material properties of a Bismuth-Telluride based static peltier device and determine its internal resistance, thermal conductivity, heat flows and efficiency.

Help Received
My Mom helped with graphics, cutting refrigerator cardboard and gluing my display board. My Dad helped with finding formulas and diagrams of heat flows. Dave Rank helped me understand heat flows better and gave me some ideas for project testing.