CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

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Project Number

S0508

Project Title

Synthesis of Bismuth Telluride Nanowires by Electrodeposition Coupled with Electrochemical Step Edge Decoration

Abstract

Objectives/Goals

The objective of this project was to find the optimal potential range and finest set of conditions for the synthesis of Bismuth Telluride nanowires.

Methods/Materials

The fabrication of Bismuth Telluride nanowires was done by a process known as Cyclic Electrodeposition/Stripping combined with Electrochemical Step Edge Decoration. This method utilizes the current generated by a redox reaction in an electrochemical cell to deposit the material onto a Highly Oriented Pyrolitic Graphite along its step edges. The structure, morphology, diameter, and other physical characteristics were noted using a Scanning Electron Microscope (SEM), while the chemical composition was analyzed using Energy-Dispersive X-Ray Fluorescence.

Results

Potential ranges between -0.04 and -0.4 volts and +0.1 to +0.5 volts were investigated in this experiment. The ranges with a negative limit of -0.04V and -0.05V had low deposition potentials, high stripping potentials, relatively high cathodic peaks, and large anodic peaks which resulted in the synthesis of few nanowires that had low diameters and a composition close to 2:3 Bismuth to Tellurium.

The ranges with a negative limit of -0.06V, -0.075V, and -0.09V and positive limit between +0.3V and +0.35V had high deposition potentials, thus allowing formation of well-structured and coalesced wires.

Potential ranges with negative limits extending beyond -0.09V and the limits +0.1V and +0.2V had relatively low deposition potentials and extremely small cathodic peaks and anodic peaks, hence causing the deposition of a plethora of nanparticles that remained disunited. The stripping potentials were small, which resulted in a high bismuth to tellurium ratio. The step edge ratio and diameters of the wires were relatively low.

Conclusions/Discussion

An optimum potential range with a negative limit between -0.06V and -0.09V and a positive limit between +0.3V and +0.35V results in the deposition of the most favorable Bismuth Telluride nanowires with an average diameters of 408 nm. These nanowires had the finest morphology and structure, and were deposited in the greatest quantities. The average chemical composition of these nanowires was 2:3.15, the closest to a desired 2:3 Bismuth to Tellurium ratio. Using the conclusions derived from this project, I can expand my research to maximize the thermoelectric figure-of-merit (ZT) for these nanowires synthesized.

Summary Statement

This project aims to synthesize the optimal Bismuth Telluride Nanowires by Cyclic Electrodeposition/Stripping, for future use in nanodevices such as thermoelectric power generators, microsystems, etc.

Help Received

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