Name(s)

Alexander Kwon

Project Number

S1712

Project Title

Synthesis and Analysis of Strontium Titanate (STO): Can It Replace Silicon for Power Electronic Applications?

Abstract

Objectives

The objectives of this project were to grow the metal oxide strontium titanate (STO), analyze its structural and electrical properties at various temperatures, and compare those properties to silicon, the current leading semiconducting material. The main hypothesis is that as STO is cooled, its electron mobility and conductivity will be better than those of silicon.

Methods

Multiple STO samples were synthesized, each taking approximately 10 hours to grow. Each STO sample was grown using molecular beam epitaxy, a thin-film deposition technique in an ultra-high vacuum environment. Electron beam evaporation was then used to deposit electrically conducting contacts onto each STO sample. As for STO analysis, x-ray diffraction was used to measure sample thickness and lattice spacing, and atomic force microscopy was used to identify surface defects. PPMS DynaCool was used to cool down the STO samples from 300 K to 2 K, and dilution refrigeration was used to further cool down the STO samples from 1 K to 0.01 K. Resistance and electron mobility were measured through Hall measurements as dependent variables of temperature change.

Results

X-ray diffraction confirmed minimized lattice spacing, and atomic force microscopy confirmed smoothness of STO samples, thus optimizing the electron mobility of STO. All STO samples had electron mobilities that were less than silicon except at very low temperatures. STO was found to have superconducting properties between 0.01 K and 0.28 K.

Conclusions

Silicon possesses higher electron mobility than STO at room temperature. However, STO possesses potential benefits over silicon: wider band gap, lower lattice spacing, higher dielectric constant, and superconducting properties. Due to these benefits, STO shows promise in high voltage power electronic applications. Future work includes increasing the critical temperature of STO and continuing to optimize its properties.

Summary Statement

This project analyzes the structural and electrical properties of strontium titanate and compares them with known properties of silicon.

Help Received

I worked under the supervision of Kaveh Ahadi and Nick Combs (graduate students) at the Stemmer Research Group at the UCSB. The research reported here made use of shared facilities of the UCSB MRSEC (NSF DMR 1720256), a member of the Materials Research Facilities Network (www.mrfn.org).