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

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Silicon is the leading semiconductor material but has inherent limitations such as low band gap and low electron mobility relative to other semiconductors. Metal oxides are currently being studied as alternatives to silicon in power electronics. One such metal oxide is strontium titanate (STO), which has semiconducting properties, tuning capabilities, and potential for superconductivity. In this project, multiple STO samples were synthesized 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 the corners of each sample. As for STO analysis, x-ray diffraction measured sample thickness and lattice spacing, and atomic force microscopy identified surface defects. A physical property measurement system was then employed to cool down samples from 300 K to 2 K, and dilution refrigeration further cooled down samples from 1 K to 0.01 K. Resistance and electron mobility were measured through Hall measurements as dependent variables of temperature change. The results showed that the STO samples had minimized lattice spacing and were very smooth, thus optimizing electron mobility. Nevertheless, all STO samples had electron mobilities that were less than silicon. But STO was found to have superconducting properties between 0.01 K and 0.28 K. In conclusion, silicon possesses higher electron mobility than STO. 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.