# 論文 / 著書情報
# Article / Book Information

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Outline of Thesis

Title: Development and precise evaluation of measurement systems for standards of temperature and electrical resistance

This thesis is composed of four chapters. The composition of the entire thesis is as the following.

Chapter 1 “General Introduction” introduces the research background, purpose, outline, and chapter structure of this paper.

Chapter 2 “Development of Acoustic Gas Thermometry system for temperature standard” describes the development of an acoustic gas temperature measurement (AGT) system. AGT is a method of measuring thermodynamic temperature by using the relationship between the speed of sound and temperature in a noble gas, and is capable of measuring thermodynamic temperature based on the Boltzmann constant. In this study, a precision temperature control system, a gas control system, an acoustic measurement system, and a microwave measurement system are constructed and integrated. As the acoustic resonator, a copper triaxial ellipsoidal cavity is used. The inner shape of the resonator is precisely measured by microwave resonance frequency measurements. In this study, the Boltzmann constant is determined by measuring the speed of sound at the temperature of the triple point of water (= 273.16 K) using argon as measurement gas. The combined uncertainty is 25 parts per million. The results are consistent with the adjusted value by CODATA, showing the soundness of measurements by the constructed AGT system.

In Chapter 3 “Development of transport measurement techniques for topological insulator for resistance standard”, measurement techniques for topological insulators are investigated. In Section 3-2, single crystal growth of $Sn_{0.02}Bi_{1.08}Sb_{0.9}Te_2S$ (Sn-BSTS), which has high bulk insulation is described. Crystal evaluation and bulk transport measurements are reported. Surface-dominant conduction is confirmed at low temperatures, indicating that Sn-BSTS is a suitable material for surface transport measurements. In Section 3-3, Sn-BSTS is thinned by exfoliation and the with the conventional electron beam lithography technique, Hall devices are fabricated. In the measurement of magnetoresistance, a cusp-like structure is observed, which is attributable to the weak antilocalization. By using the Hikami-Larkin-Nagaoka model, quantitative discussion is given on the magnetotransport. In Section 3-4, the electronic states on the upper and lower surfaces of the Sn-BSTS slice are controlled by dual gate structure, respectively. The carrier density on the bottom surface is controlled from $n_n = 8 \times 10^{11}$ cm$^{-2}$ (n-type) to $n_p = 8 \times 10^{11}$ cm$^{-2}$ (p-type). As for the top surface, p-type carriers are successfully induced by applying a gate voltage. In Section 3-5, a four-terminal Corbino device capable of measuring electrical conduction on the top surface of a Sn-BSTS flake is fabricated. By employing the resistance network model, a semi-quantitative explanation for the temperature dependence of the Corbino device is presented.

In Chapter 4 “General Conclusion”, the topics studied in this paper are reviewed, and future research prospects are given. As a future prospect of the study of AGT, evaluation of the difference between thermodynamic temperature and the international agreement temperature scale (ITS-90) is proposed, by which a better temperature scale can be approached. As for the measurement of the topological insulator, development of a new resistance standard based on the quantum anomalous Hall effect is prospected. By using the techniques developed in Chapter 3, a novel resistance standard that does not require strong magnetic fields is envisioned.