MERIT Domestic Internship Report

Engineering Faculty EEIS
MERIT 7th
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Period
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Recipient
NTT Basic Research Laboratory, Materials Science Laboratory, Low Dimensional Nanomaterials Research Group

Overview
During the above period, a research internship was conducted at NTT Basic Research Laboratories in Atsugi, Kanagawa Prefecture, Japan, to investigate the conduction properties of high-quality ferromagnetic oxide thin films. The host is Dr. Yuki K. Wakabayashi, who belongs to NTT Basic Research Laboratories. Dr. Wakabayashi was a second graduate of the MERIT program and is an expert on perovskite oxide crystal growth.

Research contents

Recently, a material group called “topological material” attracts much attention in the field of material science. In this field, when the energy band of the material has a topological nature, this feature is observed as one of the physical phenomena. If this topological feature can be used well, a new electrical device with low power consumption and high-speed communication is realized.

In this study, we focus on Weyl semimetal in the topological materials. Weyl semimetals have a linear energy dispersion near the Fermi level, which means that the carrier on this energy band has nearly zero effective mass. The quite low effective mass leads the high mobility in the material.

Ferromagnetic perovskite material $SrRuO_3$ has a long history from 1950, and it is predicted as one of the candidates of Weyl semimetals by both theoretical and experimental studies. However, there are no direct experimental evidences so far because extrinsic features such as impurities and defects easily hinder the observation of the evidence of Weyl semimetals.

We employed the machine learning assisted method and electron impact emission spectroscopy (EIES) in a molecular beam epitaxy, and obtained optimized growth condition and stable source flux. As a result, we got highest quality sample of $SrRuO_3$ thin film. We fabricated this sample into a Hall-bar device, and observed magnetotransport. Finally, we observed non-saturated linear

magnetoresistance, high quantum mobility, light effective mass, chiral-anomaly, and π phase shift in a quantum oscillation, which are the evidence of Weyl semimetal. Therefore, we proved that SrRuO3 is one of the Weyl semimetals. This is the first observation of Weyl semimetal in oxide ferromagnetic materials. We believe that this work is an important milestone in the field of topological physics with oxide materials.

Acknowledgments

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