Report of MERIT internship (in Japan)

July 19, 2016 - September 23
Department of Applied Physics, Graduate School of Engineering
3rd generation student of MERIT Yuki Ohuchi

Overview

I got the internship at Emergent Photodynamics Research Unit of RKEN Center for Emergent Matter Science (CEMS) in Wako, Saitama Prefect. from 19th of July to 23rd of September in 2016. CEMS is one of the most competing research centers which publish a lot of noticeable results in condensed matter of physics. There are many of the top researchers in the world from in and out of Japan. In this internship program, I performed magneto-optical measurement, which I had never tried, and set out to publish the results with the members of Emergent Photodynamics Research Unit, one of the research units of CEMS.

Activities

I work on the research of manipulating some physical properties, especially magnetism by electric field effect with thin films, whose thickness is a few nanometers in our laboratory. Magnetotransport properties are usually utilized in order to evaluate the magnetic properties and their modulations. On the other hand, magnetization measurement is needed for quantitative evaluations of the manipulations. However, it is a difficult experiment due to the small signal originated from the tiny volume of the thin films. We planned to optically detect the magnetization by magneto-optical effect because of its high sensitivity and small effects from impurities. But it was not a realistic idea that we constructed the measurement system by ourselves from the very beginning. We needed a lot of time, money and experiences for the measurement with sufficient accuracy in the special condition which is under external magnetic field and in low temperature achieved by cooling with liquid Helium. Therefore, I performed the experiment with the help of researchers in Emergent Photodynamics Research Unit of CEMS, who had succeeded in high-precision measurement in the similar conditions.

I had mainly two phases for improvement and verification of measurement systems in this internship. Finally the intended measurement was conducted.

As the first trial, I verified the signal stability in the recently constructed system with the new cooling system and the system for application of magnet field. Compared with the conventional system, it was expected that we could measure the optical signal in

broader temperature and magnetic field conditions by achieving lower temperature and higher magnetic field. In fact, people in the unit began to observe the stable signals in other ferromagnetic samples. However, sufficient accuracy of signal could not be obtained with my tiny samples due to the poor stability of the measured signal. The instability likely came from the fluctuation of the local temperature induced by the light source or sweep of magnetic field. I tried to suppress the fluctuation by changing the sweep rate of measurement and sample set configuration, but I had no enough improvement. More improvement of signal stability in this system remains to be solved.

Second, I attempted to utilize the conventional system, where they had already succeeded in measuring small magnetization signal in low temperature and high magnetic field conditions. Although the signal stability got greatly improved, it was suspected that the estimated temperature from the measured magnetic property was different from that we measured with thermometer. By the help of people in the Unit, we confirmed the possible causes of the temperature disagreement one by one, and eventually observed the reliable magnetization with applying electric field effect in low temperature under magnetic field.

Before this internship, I had no experience of this kind of minute optical measurements because the most of the experiments in our laboratory were fabrication of thin films and electrical transport measurements. I enriched my understanding of magneto-optical measurements by participating in the feedback of the measurements and discussion for their improvement. While I could make almost little contribution to refine the optical system in fact, thanks to help of the members with the great deal of knowledge and experiences in the Unit, we achieved to detect the small signal with high sensitivity. Also, the experiences of the setting up and reforming the measurement systems with which I have not been familiar will be my great asset not just for optical measurement but for other new experiments in the future.

We are discussing the obtained results and preparing a paper with other research collaborators.

Acknowledgements

I gratefully acknowledge the staff in CEMS for accepting this internship. Especially, Dr. Ogawa, the unit leader of Emergent Photodynamics Research Unit, made enormous contribution to fine tuning of the optical measurement systems. He also gave me constructive comments and fruitful discussions.

I am also grateful to Prof. Kawasaki and Dr. Matsuno, for planning the experiments,

adjustment of schedule, and discussion of the results.

Finally, I would like to thank MERIT program for the opportunity of this internship and support of the travelling expense.