

Quantum Materials Science Unit (Yoshinori Okada)

# FY2019 Annual Report

Quantum Materials Science Unit

Yoshinori Okada (Assistant Professor)



## Abstract

We are interested in searching novel physics and functionalities arisen from interaction between magnetism and itinerant electron in low dimension. This FY2019 is almost the 2<sup>nd</sup> for our unit. The main activity in FY2019 was growth of magnetic quantum materials and their characterization. Using our crystals, we also accelerated collaborative studies. In parallel, we kept developing design of massive ultra-high vacuum (UHV) cluster system, which was finally installed in our new lab space in lab-4 at the end of FY2019.

## 1. Member

### 1.1 Staff

- Dr. Yuita Fujisawa, (PD)
- Dr. Daichi Ueta, (PD)
- Dr. Ryutaro Okuma, (PD)

## **1.2 Graduate Student**

- Mr. Mohamed Atwa, (Graduate Student)
- Mr. Barnaby Smith, (Graduate Student)
- Mr. Markel Pardo, (Graduate Student)

## **1.3 Research interns/Visiting Scientists**

- Dr. Chia-Hsiu Hsu, (visiting scientists supported by MOST Taiwan)
- Prof. Riki Kobayashi (Ryukyu university, Japan)

## **1.4 Intern Studets**

- Mr. Wonjong Lee (UCLA, US)
- Ms. Jenniffer Garland (Northeastern, US)
- Mr. Benjamin Driesen (Northeastern, US)
- Mr. Hiroki Sawada (Keio University, Japan)

# **2. Collaborations**

## **2.1 First Principe Calculations**

- Prof. Feng-Chuan Chuang (National Sun Yat-sen University, Taiwan)
- Dr. Hsin Lin (Academia Scinica, Taiwan)
- Dr. K. H. Khoo (A-Star, Singapore)

## **2.2 Device fabrication**

- Prof. Y. Niimi (Osaka University, Japan)

## **2.3 Photoemission Experiments**

- Prof. T. Kondo (The University of Tokyo, Japan)
- Prof. M. Kobayashi (The University of Tokyo, Japan)
- Prof. K. Kuroda (The University of Tokyo, Japan)

## **2.4 Magnetic Imaging**

- Dr. A. Soumyanarayanan, (A-Star, Singapore)

## **2.5 Thermal management projects (CREST related project)**

- Prof. T. Takeuchi Tsunehiro (Toyota Technological Institute, Japan)
- Prof. K. Tanigaki (Tohoku University, Japan)
- Prof. F. Shimojo (Kumamoto University, Japan)
- Prof. K. Sato (Osaka University, Japan)

# **3. Activities and Findings**

## **3.1 Magnetic 2D materials**

We succeeded to grow wide various magnetic quantum materials including van der Waals (vdW) coupled chalcogen compounds with magnetism induced by rare-earth elements and/or transition metals. We found interesting phenomena, which are arisen from interaction between magnetism and itinerant electrons. In addition to internal sample characterization, we also started external experiments using synchrotron in SPring-8. Also, we started to provide our crystals to external colleagues to accelerate collaborative studies. Okuma Ryutaro and Daichi Ueta et al., (submitted)  
Yuita Fujisawa et al., (submitted)

### 3.2 Developing Supercritical Carbon Dioxide Ball Milling

We demonstrated unique top-down approach to make fine nanostructured Bi<sub>2</sub>Te<sub>3</sub> with a sub-10 nm grain size whilst conserving high quality crystallinity. This method is promising not only for developing Bi<sub>2</sub>Te<sub>3</sub> based thermoelectric materials but also for designing of macroscopic heterogeneous bulk systems with tailored p-n junctions, magnetic junctions, and topologically non-trivial edge states. Mohamed Atwa et al., (submitted)

### 3.3 Setting up New Lab space in lab-4

We have accelerated growth of magnetic quantum materials of either bulk and epitaxial thin films. Also, we started to move our lab space to the new building Lab-4 from Dec. 2019. In our new lab space, we setup the UHV cluster system was setup, with which we can grow various quantum materials epitaxial films and immediately visualize electronic states using single particle spectroscopies without introducing contamination due to exposing samples to the air. Likn here

## 4. Publications

### 4.1 Journals

1. Three-dimensional electronic structure in ferromagnetic Fe<sub>3</sub>Sn<sub>2</sub> with breathing kagome bilayers  
H. Tanaka, Y. Fujisawa, K. Kuroda, R. Noguchi, S. Sakuragi, C. Bareille, B. Smith, C. Cacho, S. W. Jung,  
T. Muro, Y. Okada, and T. Kondo  
Phys. Rev. B 101, 161114(R) (2020)  
<https://journals.aps.org/prb/abstract/10.1103/PhysRevB.101.161114>
2. Enhancement of coercive field in atomically-thin quenched Fe<sub>5</sub>GeTe<sub>2</sub>.  
T. Ohta, K. Sakai, H. Taniguchi, B. Driesen, Y. Okada, K. Kobayashi, Y. Niimi  
Applied Physics Express 2020, 13(4), 043005  
<https://iopscience.iop.org/article/10.35848/1882-0786/ab7f18>

### 4.2 Books and other one-time publications

Nothing to report

### 4.3 Oral and Poster Presentations

1. Anomalous and topological Hall effect in ferromagnetic Ct<sub>1-δ</sub>Te thin films

- Y. Fujisawa, Y. Okada  
Physical Society of Japan, fall meeting (2019)
2. Thickness dependence of the anomalous Hall effect in ferromagnetic Cr<sub>1-δ</sub>Te thin films  
Y. Fujisawa, Y. Okada  
Physical Society of Japan, fall meeting (2018)
3. Magnetic properties of van der Waals intermetallic compounds Ce(Te<sub>1-x</sub>Sex)<sub>3</sub>  
D. Ueta, and Y. Okada et al.,  
Physical Society of Japan, fall meeting (2018)

## 5. Intellectual Property Rights and Other Specific Achievements

Nothing to report

## 6. Meetings and Events

- The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019)  
<http://www.apws2019.jp/>  
Local Organizer (co-chair)

## 7. Other

Nothing to report.