Report of MERIT Long-Term Dispatch

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Overview

I visited Prof. Keji Lai Group at the University of Texas at Austin from 2018.9.14 to 2018.12.15, and worked on the microwave impedance microscopy (MIM), a scanning probe technique they specialize in. During my stay, I joined a project experimenting a new MIM set-up for low-temperature and high-magnetic-field measurements to learn about the technique itself and also to measure my own samples that I brought for collaboration purpose. Below I summarize what I have done during the stay.

UT Tower, a symbol of Texas Univ. at Austin.

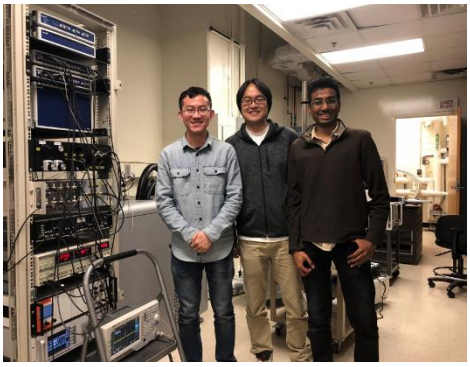
Background

In my Ph.D. research, I focus on topological materials showing exotic electric and magnetic properties, and especially I have been investigating the transport properties of topological semimetal with ultra-high mobility. So far, I have succeeded in fabricating high-quality films of a representative topological semimetal material Cd_3As_2 and have observed various quantum transport phenomena including quantum Hall effect and surface conduction by controlling the parameters such as dimensionality, carrier density, and band structure. On the other hand, Lai group has been actively studying quantum materials using a scanning probe technique called Microwave Impedance Microscope (MIM), which provides sub-micron scale real-space imaging of conductivity contrast in the sample. As topological phases including quantum Hall states typically exhibit edge/surface states which originate from the non-trivial bulk topology and lead to dissipationless conduction, MIM technique has been quite useful for clarifying the real space distribution and underlying mechanism of such unconventional edge states. For this visit, I brought several Cd_3As_2 film samples showing quantum Hall states of different origins to Lai group for the purpose to gain additional insights into the quantized transport through the MIM measurements.

Research

For realizing quantum Hall states, both low temperature and high magnetic field are necessary. Since the scanning becomes quite sensitive to the vibration noise of the set-up, so far the measurements were conducted by lifting the scanning tip away from the sample surface and recording the MIM signals without topography feedback. In that way, however, there are several problems such as limited spatial resolution due to the tip-sample distance, and signal-level change originating from the unknown

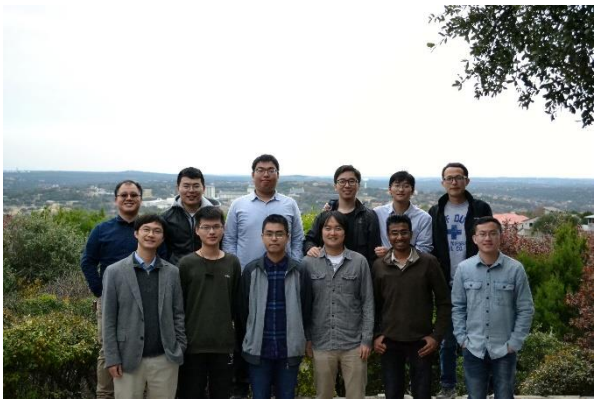
topography feature and sample surface tilting. Besides, my sample structure typically includes step heights of a few tens of nanometer, which requires the topography feedback to avoid the tip crashing. For these reasons, we decided to first establish a MIM set-up with good topography feedback under low-temperature and high magnetic field. Unfortunately, we faced a lot of technical problems such as removing the mechanical vibration transmitted to the measurement setup and adjusting the control parameters for the feedback, which took most of my stay to solve. Still, in the end, we made the system working, and measured the quantum Hall states of my samples. I could learn a lot through this try and error process, not only getting familiar specifically with MIM but also obtaining general expertise in AC circuits and scanning probe techniques. Although the experiment results were not something that deserves immediate publication, we are still discussing what would be the next step. I hope this visit can kick-off our further collaboration.



In front of the MIM set-up with my colleagues. (Left: Zhanzhi, right: Ashish, center: me)

Life during the stay

The city of Austin, as the state capital of Texas, has a typical southern open and easy-going atmosphere but at the same time, many big-name IT companies have their business sites around the downtown and UT, showing its industrial and economic development. There are also plenty of parks and sports facilities in the city, and I could fully enjoy my days off by playing tennis or by going around the town with the lab-mates and the host-family, which enabled me to keep a good balance between work and play. It was my great luck that I could experience Halloween in October and Thanksgiving in November there. I enjoyed the annual events with wonderful dinners and shopping time. Also thanks to the kind help from the Lai group students inside and outside the campus, I had no problems at all in living and eating during the stay. Through this oversea dispatch, I have got more confidence about going abroad for the future post-doc research, which is another achievement for sure.



After group Barbeque lunch.
(left in the front row: Prof. Lai)

Acknowledgements

I would like to thank Prof. Kawasaki and my MERIT mentor Prof. Ishizaka for giving me this great opportunity and Prof. Lai for warmly welcoming my visit and giving me the chance to learn a lot. I would also like to express my gratitude to my friends in Lai group for making the stay in Austin comfortable and enjoyable. I really enjoyed the time we spent together discussing research topics, playing sports, and even having a home party. I also appreciate the kind attention from Kawasaki lab. secretary Hato-san and every support from the lab-mates in dealing with the troubles happened while I was away.