

Research stay in Universitat Autònoma de Barcelona
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From 07/12/2015 to 29/02/2016, I have stayed in Prof. Dr. Aitor Mugarza group, Catalan Institute of Nanoscience and Nanotechnology (ICN2), Universitat Autònoma de Barcelona, Spain. In his group, nanoscale condensed matter physics is investigated in a complementary way of macroscopic x-ray magnetic circular dichroism (XMCD) and angle resolved photoemission spectroscopy (ARPES), and microscopic scanning tunneling microscopy (STM). This approach is novel and also close to the strategy of my Ph.D. research, and thus the stay this time was planned and readily accepted.

1. Culture and life in Barcelona

Barcelona is located in the northern part of Spain, close to France, and the biggest city next to Madrid. Through the year, it keeps high humidity and I could spend a comfortable stay thanks to a warm climate compared to Japan. Many famous places to visit are there, for example, Gaudi works represented by Sagrada Família and Park Güell, as well as old art galleries and museums. Among a whole variety of foods, fresh fish suit to the Japanese taste, and one can use so-called Boqueria (Sant Josep market) to gather all kinds of foods from meat, fish, fruit, cheese, to wine. Whenever you ask something to local people, somewhat nuisance is that they are usually incapable of managing English. It is recommended to acquire the least vocabulary needed in a daily life, before your trip.



Sagrada Família



Park Güell



Boqueria

2. Results and discussion

The primary objective is fabrication of atomically-precise graphene nanoribbon (GNR), which has a large band gap unlike single-layer graphene, on top of monatomic-layer ferromagnetic Fe_2N or insulating $\text{Cu}_2\text{N}/\text{Cu}(001)$, well-characterized materials through my

Ph.D. work. It is intriguing to investigate the difference of the structure and electronic states of GNRs grown on various substrates, a selective growth of zigzag-type GNR whose edge state is possibly spin-polarized, and an arbitral control of the band-gap width depending on width/length of GNR.

In principle, GNR can be fabricated from precursor molecules in the following two steps: (1) dehalogenation and polymerization (2) cyclodehydrogenation. Process (1) usually occurs at low temperature compared to Process (2). For example, in the Au(111) case, reaction temperatures corresponding to Process (1) and (2) are 200 and 400 °C, respectively. However, these temperature windows largely depend on strength of the bonding between molecules and substrates, as well as reactivity of molecules. Therefore, we first tried a molecular evaporation on the most simple surface to understand, clean Cu(001).

Due to its potentially high reactivity, Process (1) occurred even at room temperature (RT), and further annealing never cause Process (2) but just destruction/desorption of the molecules. In the case of RT molecular deposition on Fe₂N or Cu₂N/Cu(001), molecules were easy to desorb immediately after the annealing, and Process (1) could not be activated. Also for Fe₂N or Cu₂N on other substrates having the threefold symmetry, Cu(111) and Au(111), we tried the fabrication of GNR but it was not successful due to a different reactivity of molecules to the surface.

Fortunately, at the very end of my stay, we could succeed in a novel fabrication of GNR on Cu(111) with using a particular molecule, for which no literature reports a GNR fabrication on any substrates. Because very few examples exist to achieve GNR on the copper substrate irrespective of a precursor-molecule type, postdocs of Mugarza group will continue the characterization of this newly found GNR, and we are going to release results in the near future.

3. Spanish research style

A prototype of Spanish people, we imagine, might be the one taking a siesta after every lunch. However, this habit is no longer the fashion. Like other European scientists, they commute early in the morning, leave early in the evening, and make everything completely off on a weekend. The way they manage to balance their work and family life is ideal so that we should respect. As for experiment, a machine time for each person is of course limited, and it is the same as usual to focus on own experiment for 2 to 4 weeks once it starts, otherwise do desk works. A striking difference between us is that they unconsciously regard themselves as “friends”, rather than a professor, postdoc, and Ph.D. student in hierarchy.

That is also the case with a scientific discussion; it is something like “war” to convince or to be convinced in the right ballpark, and surely “dispute” rather than “discussion”. We Japanese students unnecessarily avoid having this kind of conflict especially with professors, so I will try to change my mind for a further fruitful discussion. The most impressive word during this stay is “As a scientist, to be independent, but not isolated.” This is similar to my impression toward foreign scientists, namely, that even young scientists are already well-independent from their supervisors. The last phrase, “not isolated”, is used here to mean that we should hear about other persons. In the last year of my Ph.D. course, one of my goals should be set to being independent considering the next step of my research life.

4. Acknowledgement

As for the stay this time, I would like to thank Prof. Aitor Mugarza for a willing consent of my stay, Dr. Cesar Moreno and other members for kind supports, Prof. Fumio Komori for recommendation of stay abroad, Assist. Prof. Toshio Miyamachi for letting me know the best laboratory to stay, and finally, MERIT organization for a great financial support.



With members of Mugarza group