Masaki Nakano
Yoshihiro Iwasa
QPEC and Department of Applied Physics, the University of Tokyo, Tokyo 113-8656, Japan.
RIKEN Center for Emergent Matter Science (CEMS), Wako 351-0198, Japan.

nakano@ap.t.u-tokyo.ac.jp

Exploring emergent phenomena in 2D materials by MBE

Bottom-up molecular-beam epitaxy (MBE) provides a complementary approach to top-down mechanical exfoliation in 2D materials research. A great success lies in the application of MBE-grown monolayer films to spectroscopic studies that require large-area monolayer samples like ARPES and STM/STS, unveiling fundamental aspects of a wide variety of 2D materials emerging at the monolayer limit. Considering the research history of semiconductors and oxides, however, one of the biggest advantages of MBE-based approach should be that we can design and create novel material systems that show emergent properties and functionalities unachievable by bulk-based approach, although such examples are very much limited in 2D materials research presumably due to difficulties in making high quality thin films.

We have recently established a versatile route to layer-by-layer epitaxial growth of a wide variety of 2D materials and their heterostructures on insulating substrates by MBE[1-3], opening a door for exploration of emergent transport phenomena arising at the monolayer limit and at the interface between dissimilar materials even based on hardly-cleavable and/or thermodynamically-metastable compounds. In this presentation, we will introduce our recent achievements including observation of giant superconducting anisotropy in extraordinarily-strained epitaxial 2D material having thermodynamically-metastable phase that could not be achieved by conventional top-down approach, and observation of emergent itinerant 2D ferromagnetism with intrinsic spin polarization in hardly-cleavable compound that are missing in its bulk counterpart. We will also introduce emergent interface transport phenomena based on those MBE-grown quantum 2D materials.

References

[1] M. Nakano et al., Nano Lett., 17 (2017) 5595.
[2] Y. Wang et al., Appl. Phys. Lett., 113 (2018) 073101.
[3] Y. Kashiwabara et al., Adv. Funct. Mater., 2019 (2019) 1900354.