Quantum materials boost quantum technology

Shuji Hasegawa[1]

[1] *Department of Physics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*
*Presenter: Shuji Hasegawa, email: shuji@surface.phys.s.u-tokyo.ac.jp

Quantum technology such as quantum computing, quantum information processing, ultra-sensitive sensors and others, are nowadays one of the most important targets of physics research. Artificial Intelligence (AI) and Internet of Things (IoT) technology may be further boost by quantum technology. Quantum materials such as topological materials, graphene and similar atomic-layer materials are key components for such technology because of their advantages in ultra-low-energy consumption and quantum phenomena such as entanglement and duality. Looking back at history of science and technology, humankind has devised artificial structures of materials such as hetero junctions and superlattice structures to obtain useful functions, which will be continued with new quantum materials.

I will mainly discuss here three kinds of two-dimensional (2D) atomic-layer materials, graphene, single-atomic-layer alloys, and van der Waals (vdW) crystals of topological insulators, which are grown by molecular beam epitaxy and characterized by some state-of-art techniques in experiments. Their unique atomic structures and electronic/spin states are origins of their interesting physical properties such as metal-atoms intercalation in graphene [1], and resulting 2D superconductivity in graphene [2,3] and atomic-layer alloys [4,5], 2D ferromagnetism, non-reciprocal transport of photocurrent [6], and spin-related transport in topological insulators [7,8].

[1] Y. Endo, M. Li, R. Akiyama, X. Yan, C. Brandl, J. Z. Liu, R. Hobara, S. Hasegawa, W. Wan, K. S. Novoselov and W.-X. Tang, Nature Nanotechnology **18**, 1154 (2023).
[2] S. Ichinokura, *et al*., ACS Nano **10**, 2761 (2016).
[3] H. Toyama, *et al*., ACS Nano **16**, 3582 (2022).
[4] A.V. Matetskiy, *et al*., Phys. Rev. Lett. **115**, 147003 (2015).
[5] T. Nakamura, *et al*, Phys. Rev. **B 98**, 134505 (2018): Appl. Surf. Sci. 479, 679 (2019).
[6] I. Taniuchi, R. Akiyama, R. Hobara, S. Hasegawa, ACS Nano, in press (2024).
[7] T. Hirahara, *et al*., Nano Letters **17**, 3493 (2017).
[8] T. Takashiro, *et al*., Nano Letters **22**, 881 (2022).