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2D AND TOPOLOGICAL MAGNETIC MATERIALS

Roland KAWAKAMI

Department of Physics, The Ohio State University, Columbus, OH 43210, USA
kawakami.15@osu.edu

Two dimensional (2D) magnets and heterostructures with topological insulators (TI) present new opportunities for energy-efficient spintronic devices due to their low magnetic volume, high spin-torque efficiency, novel quantum states, and interfacial proximity effects. Our focus is to develop robust room temperature 2D magnets, to understand the electronic, chemical, and magnetic interactions at 2D magnet-TI interfaces, and to realize spintronic functionality and novel magnetic topological states. Here, we describe our work utilizing molecular beam epitaxy for precise, atom-by-atom deposition of van der Waals materials consisting of $MnSe_2$, Bi_2Se_3, and $MnBi_2Se_4$. Starting with the epitaxial growth of $MnSe_2$ on GaSe and $SnSe_2$ base layers, we observed room temperature ferromagnetism in the monolayer limit [**1**]. Subsequent integration of $MnSe_2$ onto the topological insulator Bi_2Se_3 revealed chemical migration and dipole formation at the interface [**2**]. Specifically, we learned of the propensity for the $MnSe_2$ to intermix with the underlying Bi_2Se_3 to form a $MnBi_2Se_4$ septuple layer. By repeating the deposition of a Bi_2Se_3 followed by $MnSe_2$, we synthesized multilayer $MnBi_2Se_4$ for the first time (Figure 1a) [**3**]. This material is the cousin of the well-studied $MnBi_2Te_4$, a magnetic topological insulator exhibiting quantum anomalous Hall effect and axion insulator state. Angle-resolved photoemission spectroscopy of our $MnBi_2Se_4$ shows the presence of a topological Dirac surface state (Figure 1b). Magnetic measurements provide evidence of a layered antiferromagnetic state, similar to that observed in $MnBi_2Te_4$, but with an in-plane orientation of the magnetic moments which could give rise to alternative topological states.

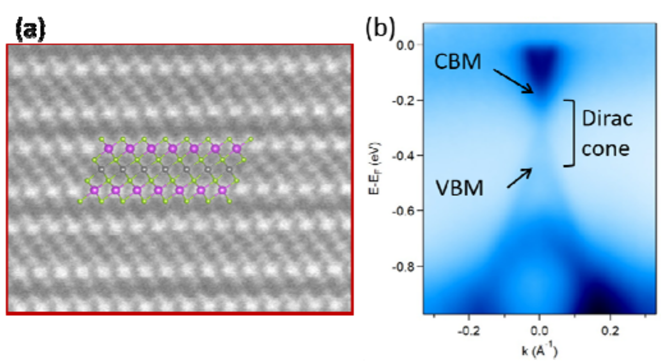

Figure 1. (a) TEM image of $MnBi_2Se_4$. (b) ARPES showing topological Dirac surface state.

References

[**1**] D. J. O'Hara *et al.*, Nano Letters **18**, 3125–3131 (2018).
[**2**] B. A. Noesges *et al.*, Phys. Rev. Materials **4**, 054001 (2020).
[**3**] T. Zhu *et al.*, arXiv:2003.07938 [cond-mat] (2020).