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Spin-valley physics and field effect on transition metal dichalcogenides

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Transition metal dichalcogenide (TMD) is attracting growing interest as two dimensional (2D) crystals beyond graphene. Of particular importance is an optoelectronic functionality based on valleytronics, which is strongly coupled with spintronics through the spin-orbit interactions, making TMD a quite unique system. Field effect transistor (FET) plays crucial roles, not only because of its ambipolar operations [1] and electric field induced superconductivity [2], but also because of its inherent broken inversion symmetry causing electric field induced Zeeman splitting [3]. In this presentation, we review our latest achievements on spin-valley physics and FET functionalities in TMD materials. We demonstrated for the first time the spin/valley polarization using spin- and angle resolved-photoemission spectroscopy. This became possible by choosing noncentrosymmetric bulk crystals. Photoluminescence circular dichroism proved that the noncentrosymmetric stacking enhances the valley polarization in bilayer, indicating that the noncentrosymmetric MoS_2 crystals are useful materials for the future valleytronics. As for the field effect, we performed systematic investigations of ambipolar FETs in MoX_2 (X = S, Se, and Te), and found new field induced superconductivity in $MoSe_2$. 2D nature of electric field induced superconductivity was unambiguously demonstrated by the anisotropic H_{c2}. We also demonstrated electroluminescence using the field effect geometry.

[1] Y. J. Zhang et al., *Nano Lett.* 12, 1136 (2012), *ibid.* 13, 3023 (2013).
[2] J. T. Ye et al., *Science* 338, 1193 (2013).
[3] H. T. Yuan et al., *Nat. Phys.* 9, 563 (2013).