**Two-dimensional layered materials: growth, characterization and device**

Yang Chai

Department of Applied Physics, The Hong Kong Polytechnic University

 The edges of layered materials have unique properties that substantially differ from the body regions. In this work, we perform a systematic Raman study of the edges of various layered materials (MoS2, WS2, WSe2, PtS2, and black phosphorus). The Raman spectra of the edges feature newly observed forbidden Raman modes, which are originally undetectable from the body region. By selecting the edge type and the polarization directions of the incident and scattered light, all forbidden Raman modes are distinctly detected. Optical simulations show that the edges of layered materials drastically distort the electromagnetic fields of both the incident and scattered light, so that the light interacts with the edges in a distinct way, which differs from its interactions with the body regions. We expect this work to contribute to a comprehensive understanding of the Raman spectroscopy of layered materials and to facilitate future exploration of the optical properties of edges. [1]

 Electrical contact between metal and semiconductor is an indispensable part in very large scale integrated circuit. The Schottky barrier (SB) at the contact region significantly affects the efficiency of charge injection and the majority carrier type of two-dimensional (2D) materials transistors. Here we construct van der Waals (vdWs) contact between metal electrode and 2D WSe2 to improve the charge injection and control the carrier type in the field effect transistors (FETs). Compared with the evaporated metal electrode, the vdWs contact suppress the Fermi level pinning effect and reduce the Schottky barrier from 128.5 meV (evaporated contact) to 55.5 meV (vdWs contact) for WSe2 transistors. Moreover, thermal emission region is widened and steep SS is obtained within a large gate voltage range. The subthreshold slope of the WSe2 device on ZrO2 is decreased from 226 mV dec-1 (evaporated contact) to 134 mV dec-1 (vdWs contact) subsequently. With HZO/Al2O3 negative capacitance gate stack WSe2 FET with vdWs contact shows minimum subthreshold slope of 18.2 mV dec-1, and the devices can be modulated by 5 × 104 within 220 mV as a result of the decreased Schottky barrier. This strategy can be also extended to other low-dimensional semiconductors for low-power electron devices. [2]

[1] Yao Guo, Weixuan Zhang, Hanchun Wu, Junfeng Han, Yongliang Zhang, Shenghuang Lin, Chunru Liu, Kang Xu, Jingsi Qiao, Wei Ji, Qing Chen, Song Gao, Wenjing Zhang, Xiangdong Zhang,\* and Yang Chai\*, ***Science Advances***, 2018

[2] Jingli Wang, Xuyun Guo, Zhihao Yu, Zichao Ma, Yanghui Liu, Ziyuan Lin, Masun Chan, Ye Zhu, Xinran Wang, and Yang Chai\*, ***IEEE IEDM***, 2018.