Strong Light-matter Interaction in Multiple Quantum-wells System Based on Monolayer Tungsten Disulfide

Zhao, Jiaxin[1], Su, Rui[1], Zhao, Weijie[1], Du, Wei[1], Liu, Xue[1], Diederichs, Carole [2,3], Liew, Timothy C. H.[1,2], Xiong, Qihua[1,2*]

[1]*Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371*

[2]*MajuLab, International Joint Research Unit UMI 3654, CNRS, Université Côte d'Azur, Sorbonne Université, National University of Singapore, Nanyang Technological University, Singapore*

[3]*Laboratoire Pierre Aigrain, Département de physique de l'ENS, Ecole Normale Supérieure, PSL Research University, UniversitéParis Diderot, Sorbonne Paris Cité, Sorbonne Universités, UPMC Univ. Paris 06, CNRS, 75005 Paris, France*

**e-mail: Qihua@ntu.edu.sg;*

Monolayer group-VI transition-metal dichalcogenides (TMDs) have emerged as a new class of 2D semiconductors and attracted extensive research interests due to their sizable direct bandgap, remarkable optical and electronic properties [1]. The tightly bound excitons with giant oscillator strength render monolayer TMDs as an ideal platform to investigate light-matter interaction in strong coupling regimes when they are integrated with optical cavities. The exciton-polaritons based on monolayer TMDs are stable at room temperature with considerable promise towards optoelectronic and valleytronic devices [2]. In addition, the layered structure can be assembled vertically to fabricate van der Waals heterostructure and enable new strategies for control of strong light-matter interactions [3]. Here, we report on the observation of the strong coupling regime in TMD quantum wells (QW) systems with tunability coupling-strengths. We incorporate multiple-QW structure using different numbers of tungsten disulfide (WS_2) monolayers that are separated by silicon dioxide (SiO_2) layers in a planar microcavity. The anti-crossing curve of the lower and upper polariton branches is revealed by using a home-built angle-resolved photoluminescence spectrometer. The vacuum Rabi splitting in the multiple QW microcavity is proportional to the square root of the number of QW. Our results not only provide fundamental understanding of the light-matter interaction in the integrated two-dimensional semiconductor and optical cavity system, but also show great promises for the application of polariton devices at room temperature.

[1] X. Xu, W. Yao, D. Xiao, & T. F. Heinz, *Nature Physics*, 2014, **10**, 343.

[2] X. Liu, et al. *Nature Photonics*, 2015, **9**, 30.

[3] S. Dufferwiel, et al. *Nature communications*, 2015, **6**, 8579.