Ultrafast Carrier Dynamics in MoS_2 Probed by Time-resolved Multi-probe Scanning Tunneling Microscopy

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Scanning Tunneling Microscopy (STM) is, without a question, one of the most excited breakthroughs in microscopic measurement technique considering its tremendous impact on experimental researches of modern physics and chemistry. However, as we all know, conventional STM and STS technique are relatively "low speed" methods due to electronic limitations, that is to say, they are not considered to be applicable to study ultrafast dynamics where sufficiently high temporal resolution is required. To overcome this major disadvantage in temporal resolution of STM, our group has proposed a time-resolved "Optical Pump-probe STM (OPP-STM)"[1] which is turned out to be a quite powerful and reliable system in observing ultrafast carrier and electron spin dynamics in semiconductors, with achieving high temporal while maintaining the spatial resolution. Here we present a recently developed multi-probe OPP-STM technique, to probe ultrafast carrier dynamics of few-to-monolayer MoS_2 thin films, a typical 2-dimensional Transition Metal Dichalcogenides (TMDs).

Compared with its single-probe predecessor, multi-probe OPP-STM is able to detect the time-resolved tunneling current flowing between two (or more) tips with floating substrate. From this perspective, multi-probe OPP-STM is suitable especially for low-dimensional samples with intriguing surface/interface properties, such as monolayer MoS_2 on insulating substrate, and its nanostructures[2]. Henceforth, Multi-probe OPP-STM can potentially be a very powerful technique to observe varieties of transient dynamics in such samples with considerably high temporal and spatial resolution. One of the obtained results is shown in figure 1. The sample is few-to-monolayer MoS_2 on Boron Nitride substrate, all experiments are performed at 300K in UHV and different tip combinations can be applied. Figure 1 clearly reveals that our multi-probe OPP-STM system is able to probe transient carrier dynamics in MoS_2. Moreover, spatially resolved experiments such as evaluating carrier or spin dynamics at TMDs interfaces, or transportation dynamics, would be quite promising to be realized exclusively on this multi-probe OPP-STM system. Details about the experimental design as well as more data will be introduced in the presentation.

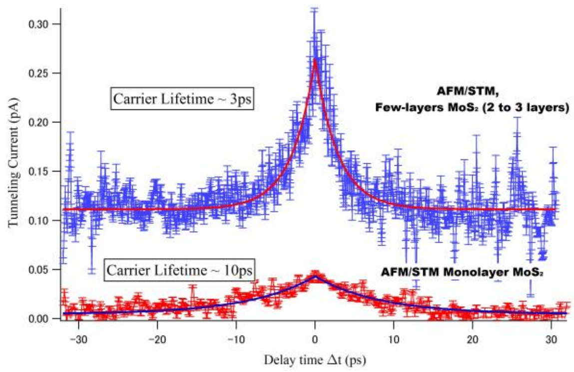

Figure 1. Carrier lifetime data on different locations of the MoS_2 sample probed by multi-probe OPP-STM.

References:

[1] S. Yoshida, et al. *Nature Nanotechnology 9*, 588-593, 2014.

[2] Y. Kobayashi, et al. *Scientific Reports 6*, 31223, 2016.