Transient Dynamics of MoS_2 Observed by Multi-probe Optical Pump-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, we also have to admit that, conventional STM as well as STS are not suitable for ultrafast time-resolved applications due to the limitation in electronics. Scientists worldwide had been making great efforts in improving STM's temporal resolution, without compromising its high spatial resolution, namely, to develop a "Time-resolved STM". One of the successful attempts is the "Optical Pump-probe STM (OPP-STM)" that our group has proposed, which is turned out to be a quite powerful and reliable system in observing ultrafast carrier[1] and electron spin dynamics[2] in semiconductor samples, with both high temporal and spatial resolution simultaneously. Here we present a recently developed multi-probe OPP-STM technique, to probe transient carrier dynamics of few-to-monolayer MoS_2 thin films, a typical 2-dimensional Transition Metal Dichalcogenides (TMDs).

An obvious advantage of multi-probe OPP-STM over its single-probe predecessor is that 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 and its nanostructures. Multi-probe OPP-STM can potentially be a very powerful technique to observe 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. 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 achieve exclusively on this multi-probe OPP-STM system. Details about the experimental design as well as more data will be introduced in the presentation.

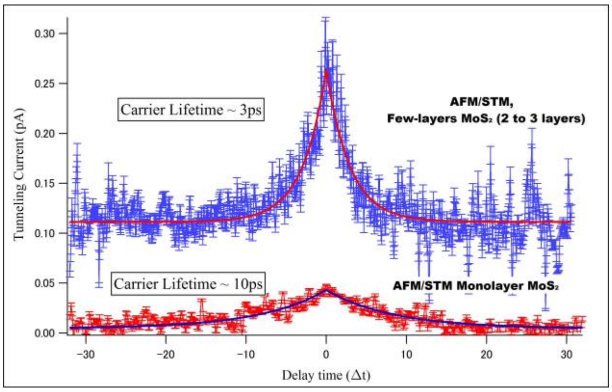

Figure 1. Carrier lifetime data on different locations of the MoS_2 sample probed by multi-probe OPP-STM.

References:

[1] Y. Terada, et al. *Nature Photonics 4*, 12 869-874, 2010.

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