Nanoscale spatially resolved observation of photoexicited carrier dynamics in WS_2/WSe_2 intralayer heterostructure device

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In recent years, the transition metal dichalcogenides (TMDCs) semiconductors have attracted much attention due to their remarkable optoelectronic properties such as a direct bandgap in a visible range and an ultrafast photo response. In addition, creating heterojunctions and alloys would enable band engineering by combining various compositions. So far, it has attempted to control band alignment by creating intralayer/interlayer heterostructures [1]. In case of the intralayer heterostructure, a large band offset difference can be expected without suffering by intralayer coupling since there is no spatial overlap. However, it is also necessary to consider the nanoscale effect of the strain induced by the junction of different lattice constant materials. It is desired to directly evaluate the dynamics of photoexcited carriers as well as the structure on the nanoscale. The purpose of this study is to clarify the dynamics of carrier recombination and migration on the nanoscale for WS_2/WSe_2 intralayer heterostructure devices.

The in-plane WS_2/WSe_2 heterostructure was grown within a single layer by switching the source gas during chemical vapor deposition (CVD) on SiO_2/Si substrate. Then, an electrode pattern was formed by a photolithography process. In this experiment, we used the photoexcited multi-probe STM which was originally developed by our group. The optical microscope image of the sample is shown in Fig.1. The STM observation and time-resolved measurement were performed by irradiating a femtosecond pulse laser (λ = 633 nm, a pulse width 400 fs) at the hetero interface indicated by the red arrows in the figure. Figure .2 shows the examples of time-resolved spectrum obtained by placing STM probe on the WS_2 and the WSe_2 region, respectively. Two lifetimes were obtained on both regions. The fast decay component (~1.2 ps) may be attributed to the Auger recombination process. As for the long decay component time constant and signal intensity were different each other, which is considered to be associated with the carrier transfer process due to charge separation in each region. This technique is expected to play an important role in the researches to develop advanced functional devices with nanoscale structures.

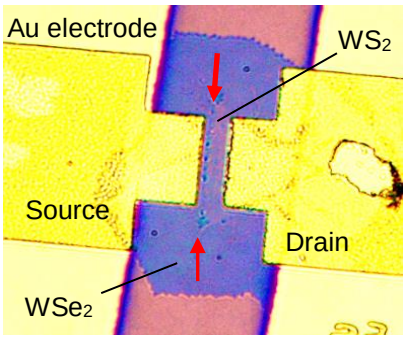

Fig 1 Optical microscope image

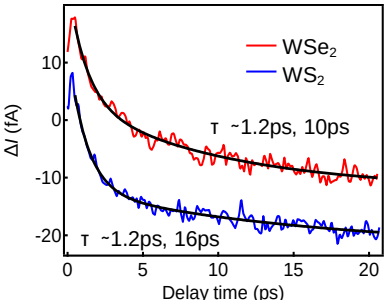

Fig 2 Time-resolved spectra

[1] C. Zhang, Nature Nanotechnol. 13, 152 (2018)