Analysis of Trap-related Conduction Dynamics in Atomically Thin Materials by an Optically Excited Multiprobe Setup

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Atomically thin transition metal dichalcogenides (TMDs) semiconductors that has strong light-matter interaction exhibit remarkable performance of photoresponsivity. On the other hand, although the response time is as fast as 10^{-8} s for Si, that of TMDs is as slow as 10^{-1} ~ 10^{-3} s, and monolayer MoS_2 devices have large variations in response time for each device [1]. The slow response is considered to be due to the carrier trapping via defect states in channel and the channel-substrate interfaces etc. Therefore, we have developed a method for measuring local trap-related photoconduction dynamics at an arbitrary position.

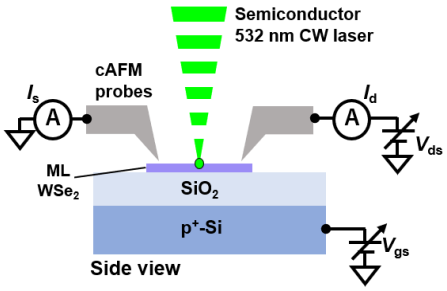

Fig. 1 Optically excited multiprobe setup for measuring ms photoconduction dynamics.

Here, we conducted an experiment using an originally developed photoexcited multiprobe system that is combined with continuous light to measure the ms-scale optical response [2]. The measurement setup is shown in Fig.1. Two probes are brought into contact with any point on a monolayer WSe_2, and continuous light (532 nm, 0.5 mW) with on-off modulation is irradiated between the probes. The optical response dynamics of ms-scale were obtained by extracting the current response immediately after turning off and averaging these values several times. Figure 2 shows the V_{gs} dependence of the results. Along with the steady-state current, the transient responses were strongly dependent on V_{gs}, and a two-component exponential decays were obtained. Combined with the analysis of $|I_s|$ - $|I_d|$, it was clarified that the hole emission from the trap levels occurs at t < 30 ms, and the electron capture process may affect at the longer time. By combining with atomic-scale observation by STM, it's expected to develop into a powerful tool for local dynamics evaluation via trap levels [3].

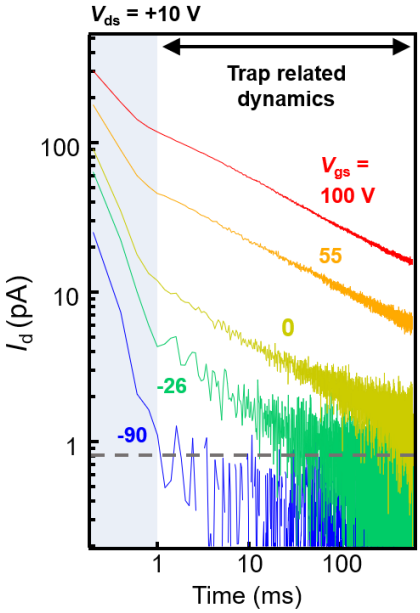

Fig. 2 V_{gs} dependence of trap-related transient response.

[1] M. M. Furchi et al, *Nano Lett.* 14, 6165 (2014). [2] H. Mogi et al, *Appl. Phys. Express* 12, 045002 (2019).
[3] H. Mogi et al, *Jpn. J. Appl. Phys* (2022) in print.