Ultrafast Dynamics in Bulk and Monolayer MoS$_2$ Measured with Femtosecond Pump-Probe Technique

Xianghai Meng, Department of Mechanical Engineering, The University of Texas at Austin, Austin, TX 78712, Wenzhi Wu, Department of Electrical Engineering, Heilongjiang University, China, Avinash Nayak, Department of Electrical and Computer Engineering, The University of Texas at Austin, TX 78712, Jung-Fu Lin, Department of Geological Sciences, The University of Texas at Austin, Austin, TX 78712, Deji Akinwande, Department of Electrical and Computer Engineering, The University of Texas at Austin, TX 78712, Yaguo Wang, Department of Mechanical Engineering, The University of Texas at Austin, Austin, TX 78712 — MoS$_2$ is a typical material of transition-metal dichalcogenide family. It exhibits unique properties when thickness reduces to monolayer. Recent studies have shown strong photoluminescence (PL) and high carrier mobility on monolayer MoS$_2$, which makes it a promising candidate for future photonic and field-effect transistor (FET) applications. Our ultrafast measurement utilizes optical 400nm-pump 800nm-probe spectroscopy to reveal the relaxation dynamics of photo-excited carriers in both bulk and monolayer MoS$_2$. Measurement is carried out at ambient pressure for different pump fluences. Both a fast and a slow carrier lifetime are acquired in monolayer MoS$_2$ due to different carrier scattering mechanism. Carrier lifetimes are measured at different pump fluences, from which we propose possible carrier relaxation mechanisms. In suspended bulk MoS$_2$, coherent acoustic phonons with a peak frequency around 38GHz are observed. Phonon lifetime and amplitude at different pump fluences have also been investigated.

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