Time-resolved measurement of tunneling current on $MoTe_2$ using multi-terahertz STM

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The combination of scanning tunneling microscopy (STM) and femtosecond lasers have been used to develop a measurement method with high resolution in both time and space [1]. Recently, a technique using half-cycle terahertz (THz) electric field has attracted much attention to change the bias voltage instantaneously while suppressing the effect of thermal expansion of STM tip [2]. We have developed sub-cycle multi-THz up to 30 THz to improve the temporal resolution of STM [3] aiming to reveal ultrafast phenomena such as electron-lattice interaction in real space. In this study, we performed time-resolved measurements of tunneling current from a transition metal dichalcogenides under inter-band excitation using subcycle multi-THz pulses.

The fundamental wave of optical parametric amplifier (OPCPA) (wavelength: 680 nm - 940 nm, pulse duration: 8.5 fs, repetition rate: 4 MHz, pulse energy: 0.8 μJ) was injected into a 30 μm thick of a GaSe crystal, and subcycle multi-THz pulses were generated by optical rectification. Then the pulses were guided into a STM in an ultra-high vacuum chamber colinearly with a fundamental beam. In STM, Pt/Ir tip and bulk $MoTe_2$ sample were used for the measurement.

Figure 1 shows the result of ultrafast modulation of the tunneling current under interband excitation. The bias voltage was 15 mV and the set point was 40 pA. The measured curve indicates the tunneling current were modulated by the multi-THz wave. The rise time and decay time were 220 fs and 750 fs respectively. These responses were originated from the ultrafast dynamics of excited carriers in the sample.

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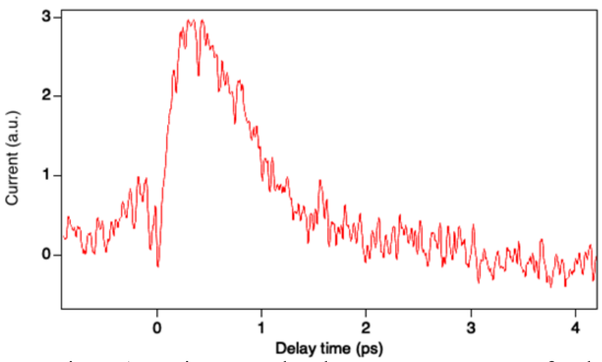

Fig. 1, Time-resolved measurement of the modulation of tunneling current.