Investigation of luminescence from a localized plasmon induced by THz-field-driven tunneling electrons

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A single-cycle terahertz (THz) electric field has been installed to drive tunneling electrons in a scanning tunneling microscope (STM), which enables to track and control the carrier dynamics in matters and the molecular motion[1-3]. While the THz-STM is capable of conducting real-time investigations of these dynamics, detection of energy dissipations accompanying quantum conversions have been out of reach, since it measures only the THz-field-driven tunneling current. In this work, we combined a photon detection system[4] with THz-STM (Fig. 1a) for understanding and describing the energy dissipation of THz-field-driven electrons, since the photons emitted during the energy dissipations provide fruitful information of the energy dynamics.

Single-cycle THz pulses were generated via optical rectification of laser pulses from a Yb fiber laser (1030 nm, 100 kHz, 700 mW) in a $LiNbO_3$ prism using a tilted-pulse-front configuration (Fig. 1b). The generated THz pulses were guided into a low-temperature STM and focused to the junction (Fig. 1a). Figure 1c shows a current trace on Ag(111) surface, where the current induced by the THz pulses was measured as 2.65 pA. Based on the Simmons model for the electron tunneling probability[1,2], the maximum magnitude of the voltage applied by the THz pulse was estimated to be ~6.5 V. Figure 1d shows STM luminescence spectra when the THz pulse was either introduced to the STM (red) or blocked (grey). Whereas no peak is seen in the grey spectrum, a broad peak ranging from 1.3 eV to 2.3 eV appears in the red spectrum, which is originated from the radiative decay of a plasmon localized in the gap. In this presentation, we would like to discuss the mechanism of plasmon excitation by THz-field-driven electrons.

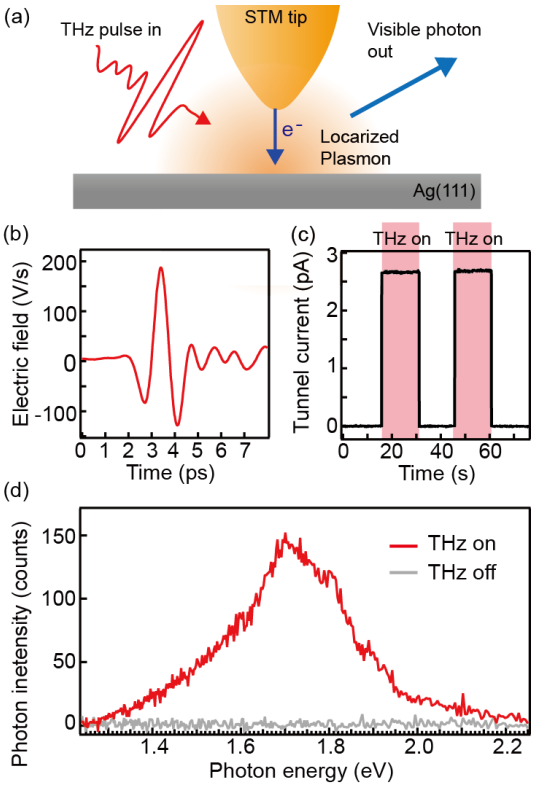

Fig. 1.
(a) Schematic image of experimental setup.
(b) Temporal profile of a THz electric field.
(c) Current trace with and without THz pulses.
(d) THz-STL spectra of Ag(111) (V_s = 0 V, t = 120 s) with (red) and without (grey) THz pulses.

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