Nanoscale visualization of carrier dynamics in semiconductors by femtosecond time-resolved STM

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Understanding and control of carrier dynamics in nanoscale structures are the key factors for advancing nanoscale science and technology. Recently we have developed a femtosecond time-resolved scanning tunneling microscope (STM), a shaken-pulse-pair excited STM (SPPX-STM) [1, 2], which enables us to visualize carrier dynamics in the potential landscape of nanostructures. In this presentation, we demonstrate the visualization of dynamics of photoexcited carriers modulated by the inner potential in a GaAs-PIN junction.

In a SPPX-STM measurement, the tunnel gap of an STM is illuminated by a sequence of paired pulses, and the tunneling current I is measured as a function of delay time t_d between the pulse pair. A GaAs p-i-n junction was grown by molecular beam epitaxy. The STM-SPPX measurements were performed on a cleaved clean surface at room temperature in ultrahigh vacuum.

The dominant decay process of photocarriers is recombination in p- and n-regions while it is drift and diffusion in i-region. For typical semiconductors like GaAs, the latter process is faster. This expectation is visualized by a series of $\Delta I\ (t_d) \equiv I(t_d)-I(\infty)$; The value of $\Delta I\ (t_d)$, corresponding to the photocarrier density at t_d after excitation, decreases faster in i-region than in p-region. These features are quantitatively observed in the carrier lifetime image. Details will be discussed at the presentation.

References:

[1] http://dora.bk.tsukuba.ac.jp/ [2] Y. Terada et al., Nanotechnology **18,** 44028 (2007).