Ultrafast photo-induced carrier dynamics observed by pulse-pair excited scanning tunneling microscopy

Masahiro Aoyama, Hiroyuki Kondo, Naohiro Ebisawa, Yasuhiko Terada, Osamu Takeuchi, and Hidemi Shigekawa
Institute of Applied Physics, CREST, University of Tsukuba, Tsukuba, 305-8573 Japan

We have developed a pulse-pair excited scanning tunneling microscopy (PPX-STM), STM combined with femtosecond pulse laser (fs-laser) [1], which provides us with ultimate spatial and temporal resolutions simultaneously. With the PPX-STM, we measure time-averaged tunnel current \( I(t_d) \) induced by a train of pulse-pairs as a function of the delay time \( t_d \) of the pulse pair. Tunnel current gives us the high spatial resolution of STM and does the delayed pulse-pair the high temporal resolution of fs-laser.

Figure 1(a) shows an example of PPX-STM signal (gray line) obtained for a GaN\(_x\)As\(_{1-x}\) (\( x=0.36\% \)) sample and the calculated result of fitting (black line). Tunneling current \( I(t_d) \) decays with a time constant of 360ps, which is close to the carrier lifetime, 370ps, obtained using the conventional optical pump-probe measurement technique.

Figure 1(b) is a result obtained with different measurement conditions of excitation, different wavelength and intensity. As is shown in Fig 1(b), the decay time of tunneling current \( \Delta \) \_decay has two components which are shorter and longer than the carrier lifetime.

These results indicate that \( \Delta \) \_decay reflects not only carrier lifetime but also the other carrier dynamics such as diffusion and drift, suggesting the high potential of SPPX-STM as a nanoscale probe with excellent temporal resolution. Details will be discussed.

Reference
http://dora.ims.tsukuba.ac.jp/