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

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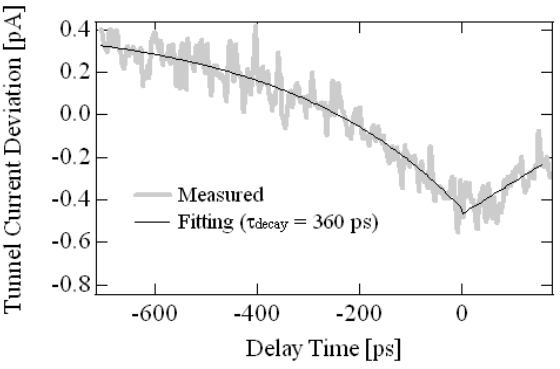
We have developed a pulse-pair excited scanning tunneling microscopy (PPX-STM), STM combined with femtosecond pulse laser (fs-laser) [1], which provides us with ultimate spatial and temporal resolutions simultaneously. With the PPX-STM, we measure time-averaged tunnel current $I(t_d)$ induced by a train 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.

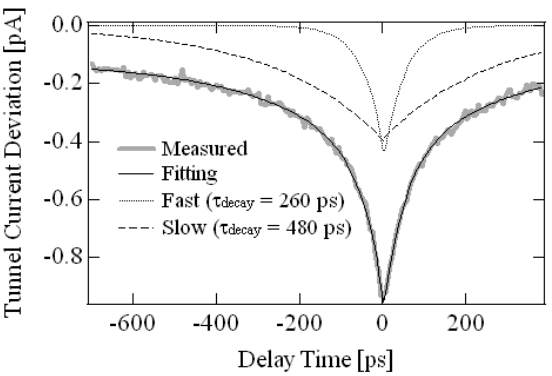
Figure 1(a) shows an example of PPX-STM signal (gray line) obtained for a GaN_xAs_{1-x} (x=0.36%) sample and the calculated result of fitting (black line). Tunneling current $I(t_d)$ decays with a time constant of 360ps, which is close to the carrier lifetime, 370ps, obtained using the conventional optical 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 τ_{decay} has two components which are shorter and longer than the carrier lifetime.

These results indicate that τ_{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.



(a) 900nm, ~0.1mW, 4V, 200pA,



(b)800nm, ~0.1mW, 4V, 100pA,

Fig. 1 PPX-STM signals GaN_xAs_{1-x} (x=0.36%) obtained with different measurement conditions. Carrier lifetime obtained using optical pump-probe technique is 370ps.

Reference

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

[1] O. Takeuchi et al., *Appl. Phys. Lett.* **85**, 3268 (2004).