What can we observe by Femtosecond time-resolved STM?
- Carrier dynamics probed with ultimate spatial and temporal resolutions -

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Understanding and evaluating the ultrafast carrier dynamics in functional components at the nanoscale faces difficult but unprecedentedly important issues; when it comes to responding to ongoing strong requirements for the development of smaller and faster semiconductor devices. Pulse-Paired excited scanning tunneling microscopy (PPX-STM) [1, 2] is a nanoscale imaging technique that enables us to directly reveal how carriers behave in, for example, semiconductors with subpicosecond time resolution. PPX-STM is the combination of STM with optical excitation using femtosecond laser pulse pairs (Fig. 1(a)), which provides ultimate spatial and temporal resolutions. In PPX-STM measurements, the tunnel gap of STM is illuminated by a sequence of paired pulses and the corresponding change in tunneling current is measured as a function of delay time between the pulse pair. The first pulse excites the sample and the transient tunneling current changes accordingly. If the sample is still excited upon the second pulse illumination, the transient current triggered by the second pulse is different from that by the first pulse, depending on the delay time. Therefore, the detected current reflects the relaxation process of carriers in the sample.

Figures 1(b) and (c) show PPX-STM signals from low-temperature grown GaNAs and n-type GaAs samples. Each signal exhibits a decay time close to the carrier lifetime of the sample. The underlying physics in PPX-STM measurement will be discussed together with the recent development of the system that has enabled us to obtain spatial mapping of carrier dynamics.

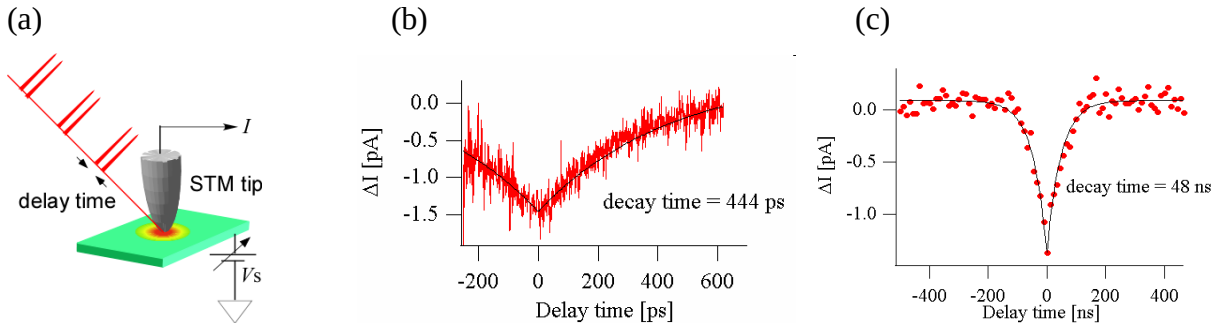

Fig. 1. (a) Schematic of PPX-STM. PPX-STM spectra obtained for (b) low-temperature grown GaNAs and (c) n-type GaAs (10^{18}cm^{-3}).

References

1) Y. Terada, M. Aoyama, H. Kondo, A. Taninaka, O. Takuechi and H. Shigekawa, Nanotechnology 18, 44028 (2007).

2) H. Shigekawa, O. Takeuchi and M. Aoyama, Sci. & Technol. of Advanced Materials, 6, 582 (2005).