

# Carrier dynamics influenced by surface states on Co/GaAs

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Localized gap states in semiconductors exchange carriers with valence or conduction bands. Probing and understanding the carrier dynamics between confined electronic states and the states in the bands become increasingly important, as the size of semiconductor devices becomes smaller. This could be possible by shaken pulse-paired excited scanning tunneling microscopy (SPPX-STM) [1], which enables us to directly image how carriers behave in semiconductors with sub-picosecond temporal and atomic-scale spatial resolutions. Here we report on the influence of surface states on carrier dynamics investigated by SPPX-STM.

For SPPX-STM measurement, the tunnel gap of STM is illuminated by a sequence of paired pulses (Fig. 1) and the corresponding change in tunneling current  $\Delta I$  is measured as a function of delay time between the pulse pair. Co was deposited onto a cleaved GaAs surface in an ultrahigh vacuum chamber. The Co particles are well isolated and almost the same in size (Fig. 2). We measured time-resolved tunneling current  $\Delta I$  vs. delay time for GaAs and Co sites (Fig. 3). For GaAs,  $\Delta I$  exhibits a slow component. In contrast, a fast component is seen in  $\Delta I$  for Co. This difference is explained by the existence of the surface state on the Co site, which is absent for GaAs; The carrier trap and recombination at the Co-derived surface state may be responsible for the observed fast component. Details will be discussed at the presentation.

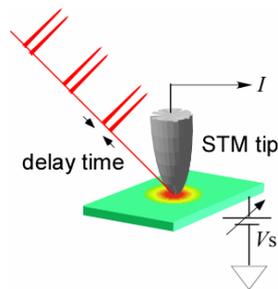


Fig. 1 (a) Schematic of measurement.

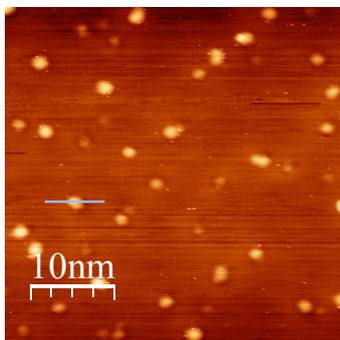


Fig. 2 STM images of Co particles on GaAs.

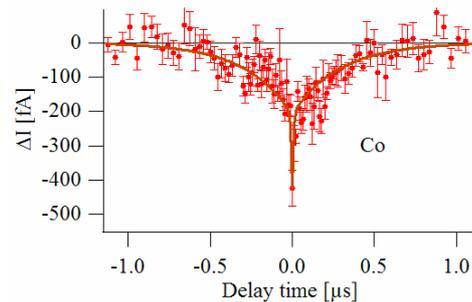
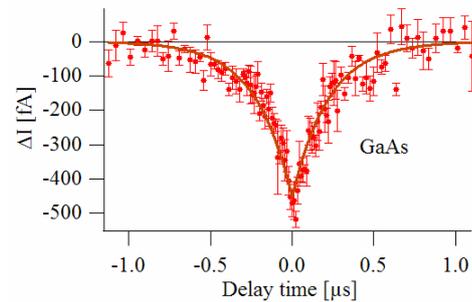


Fig. 3 Time-resolved tunneling current  $\Delta I$  obtained for (upper) GaAs and (lower) Co.

## References

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