# Carrier Dynamics in GaAs P-I-N Structures Investigated by Femtosecond Time-Resolved STM

Atsushi Okubo, Yasuhiko Terada, Shoji Yoshida, Munenori Yokota,
Osamu Takeuchi, and Hidemi Shigekawa
Institute of Applied Physics, CREST, University of Tsukuba, Tsukuba, 305-8573 Japan
http://dora.bk.tsukuba.ac.jp/

Nanoscale imaging of ultrafast phenomena in materials used in nanotechnology is a promising technology for material science. As an unprecedented demonstration of such visualization, here we show images of local minority-carrier lifetimes in semiconductor heterostructures using femtosecond time-resolved scanning tunneling microscopy (STM), shaken-pulse-paired excited STM (SPPX-STM) [1].

SPPX-STM is the combination of STM with optical excitation using femtosecond laser pulse pairs, which provides ultimate spatial and temporal resolutions. In SPPX-STM measurements, the tunnel gap of STM is illuminated by a sequence of paired pulses and the corresponding change in tunneling current $\Delta I$ is measured as a function of delay time $t_d$ between the pulse pair. SPPX-STM provides spatial and temporal information on optically-induced phenomena which depends on material systems. In case of semiconductors, SPPX-STM measurements illustrate local decay processes of photo-generated minority carriers.

The sample used was GaAs p-i-n junction grown by molecular beam epitaxy. SPPX-STS measurements were performed on a cleaved clean surface at room temperature in ultrahigh vacuum. The duration and wavelength of the pulse laser were 150 fs and 800 nm, respectively.

The decay process of photo-generated minority carriers is expected to be inhomogeneous in p-i-n junction. The dominant process is recombination in P or N regions while it is drift and diffusion in I region. For typical semiconductors like GaAs, the latter process is faster. This expectation is clearly illustrated by a lifetime image across the p-i boundary which reveals that the lifetime in I region is shorter than that in P region. Details will be discussed at the presentation.

**References**

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