**Origin of SPPX-STM signals from semiconductor**

M. Yokota[1], S. Yoshida, Y. Mera[2], O. Takeuchi, and H. Shigekawa
[1]Institute of Applied Physics, University of Tsukuba, Tsukuba, 305-8573, Japan.
http://dora.bk.tsukuba.ac.jp

To explore transient carrier dynamics in organized nanostructures, we recently have developed shaken-pulse-pair-excited STM (SPPX-STM) [1]. In SPPX-STM, STM junction is illuminated by a sequence of optical pump and probe pulses and the corresponding change in tunneling current $\Delta I$ is measured as a function of delay time between the pump and probe pulses. According to our model (Fig. 1), the exponential decay of $\Delta I$ against delay time reflects the lifetime of minority carriers excited by a pump pulse. To confirm the model, in this study, we have studied, for example, the influence of optical intensity on the photocarrier dynamics appearing in spectra.

Figure 2 shows typical SPPX-STM spectra obtained for a n-type GaAs (110) with two different optical intensities. Under the lower intensity, single exponential decay (τ~ 240ns) was observed, whereas two exponential decays (τ~10ns and 100ns) were detected under the higher intensity. The faster component (τ~10ns) is attributed to the bulk side carrier recombination. In fact, the value is in good agreement with that obtained by optical pump-probe method. On the other hand, the slower components (τ~100 and 240 ns) are considered to reflect the lifetime of the holes accumulated at the surface. Under a reverse bias voltage condition, depletion of electrons occurs at the surface due to upward band bending as shown in Fig. 1, therefore, the trapped holes can decrease only via thermionic emission from the surface to bulk-side. Thus, the decay time of surface carriers depends on the magnitude of surface band bending, i.e., the laser intensity that determines the surface photo voltage (SPV). A high intensity laser pulse produces a large SPV, a less band bending, resulting in the longer decay constant. The obtained result is in good agreement with the model. However, there are some points remained to be clarified. For example, why the fast component appears only for the case of low intensity excitation? Details will be discussed at the colloquium.

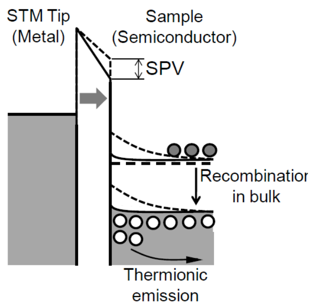


Fig.1: Band diagram of STM tunnel junction with photocarrier relaxation processes.

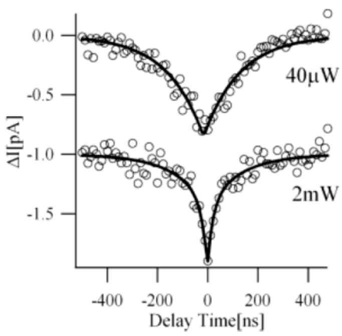


Fig.2: SPPX-STM spectra obtained for two different laser intensities.

[1] Y. Terada, S. Yoshida, O. Takeuchi, H. Shigekawa, Nature Photonics, 4. 12 (2010) 869.

[2]On leave from University of Tokyo.