# Optical excitation dependence of carrier relaxation processes appearing in SPPX-STM on semiconductor

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In order to explore the transient carrier dynamics in organized nanostructures, we have recently developed shaken-pulse-pair-excited STM (SPPX-STM). In SPPX-STM measurement, 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, the exponential decay of $\Delta I$ against delay time reflects the lifetime of minority carriers excited by a pump pulse. However, the validity of the model has not yet been examined in detail. To confirm the model, in this study, we have studied the influence of optical intensity on the carrier decay process appearing in SPPX-STM spectra

We measured SPPX-STM spectra by changing the intensities of pump and probe pulses independently. Figure1 shows two SPPX-STM spectra obtained with two different pump pulse intensities. The carrier lifetime $\tau$ is shorter in the spectrum obtained under the higher pump pulse intensity condition. Figure 2 shows the pump and probe pulse intensity dependence of $\tau$. $\tau$ becomes longer with the pump pulse intensity being decreased when the pump pulse intensity was lower than 10μW, while $\tau$ was insensitive to the probe pulse intensity. According to our model, $\tau$ under a low optical intensity represents the lifetime of surface carriers trapped during photoexcitation due to the potential formed by the tip induced band bending (TIBB) (Fig.3). These surface carriers decay through diffusion into bulk by thermal excitation overcoming the energy barrier formed by TIBB. Since surface photovoltage generated by a pump pulse excitation reduces the amount of TIBB, surface carrier lifetime becomes shorter when sample is excited by high-intensity pump pulse. In addition, insensitiveness of $\tau$ to probe pulse intensity clearly indicates that carrier dynamics obtained from SPPX-STM spectra are not affected by probe pulse intensity. Details will be discussed at conference.

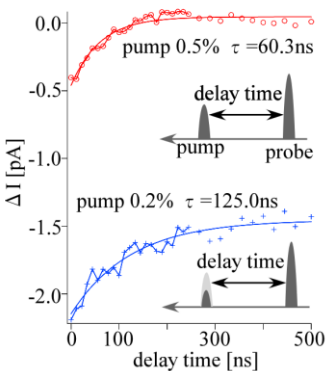


Fig.1 $\Delta I$ measured with two different pump pulse intensity as a function of delay time.

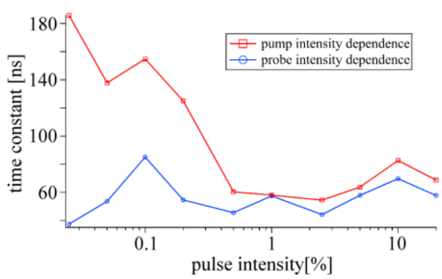


Fig.2 Light intensity dependence of carrier decay constant.

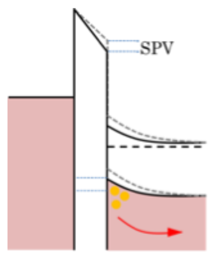


Fig.3 Schematic illustration of bandbending relaxation.