Spin dynamics in GaAs

probed by optical pump-probe STM

S. Yoshida, Y. Aizawa, O. Takeuchi, Y. Mera and, H. Shigekawa

Institute of Applied Physics, University of Tsukuba,

Tsukuba, Ibaraki 305-8573, Japan, http://dora.bk.tsukuba.ac.jp

Abstract: With a new modulation technique of optical pulses, femtosecond time-resolved STM has been modified to detect ultrafast spin dynamics. By applying the new microscopy technique, ps-range spin dynamics in GaAs have been successfully probed by STM for the first time.

To advance current emerging fields of semiconductor spintronics, it is essential to develop the methods to manipulate spin states in semiconductor quantum structures. Spin flip and dephasing, for example, occur through scattering by phonons and impurities. In addition, local structures, surface, and interfaces are known to strongly affect spin lifetime. To understand such processes in spin dynamics in more detail, it has been eagerly desired to develop the techniques enabling to probe spin dynamics with high spatial and temporal resolutions.

We have realized a new microscopy technique enabling to detect spin dynamics using time-resolved STM (TR-STM). In the microscopy, a sample surface is excited by a sequence of laser-pulse pairs of circularly polarized (CP) light to generate spin-polarized carriers in the sample. Since the spin direction of excited carriers depends on the polarization of CP pulses (left hand or right hand), generation of photocarriers by the same CP pulses is suppressed due to Pauli exclusion principle, while that by anti-CP pulse pairs is not. Therefore, the mechanism similar to absorption bleaching enables us to detect spin dynamics. Spin relaxation processes were observed by measuring ΔI as a function of delay time Δt between pulse pair (Fig.2(a)). In the case of an undoped GaAs, a decay constant around 6 ps was obtained, which is in good agreement with the electron spin lifetime (7.8 ps Fig.2 (b)) obtained by optical pump probe reflectivity (OPPR) measurement. We have simultaneously observed a component with a long lifetime (~1 ns Fig.3), which did not appear in OPPR measurement.

Details will be discussed with other results at the conference.

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

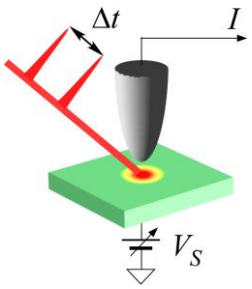

Fig.1 Schematic of time-resolved STM

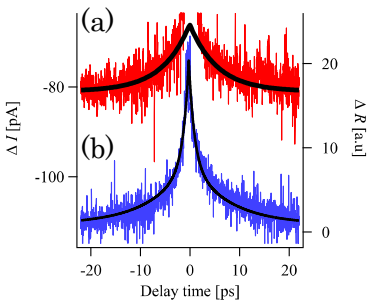

Fig.2 (a) TR-STM and (b) OPPR spectra obtained for an undoped GaAs.

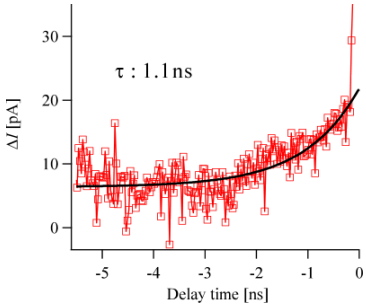

Fig.3 TR-STM component with a long decay constant.