Circularly-polarized light modulation for the detection of spin dynamics by Time Resolved STM

Y. Aizawa, S. Yoshida, Y. Mera, O. Takeuchi, and H. Shigekawa
Institute of Applied Physics, University of Tsukuba Japan
Tennodai 1-1-1, Tsukuba, Ibaraki 305-8573, Japan. http://dora.bk.tsukuba.ac.jp

For the past three decade, electron spin relaxation process in semiconductors has attracted much attention for the development of spin based devices for the storage, transport, and processing of information. A microscopic measurement technique has been required to clarify the spin relaxation mechanisms in more detail and to study the influence of local structure such as impurity, surface and interface. For direct band gap semiconductor such as GaAs, circular polarized (CP) light has proven to be powerful tool to manipulation and study of the electron spin dynamics.

In this study, we have developed the new CP modulation techniques to measure the local spin dynamics using femto-second time resolved STM (TR-STM). Experiments have been carried out to measure the spin lifetime of undoped GaAs. Laser pulse pairs with a certain delay time excite the sample repeatedly (fig.1) and each pulse was circularly polarized to excite spin polarized carriers in a sample. Since the spin direction of excited photocarriers depends on the polarization of CP pulses (left hand (L_{CP}) or right hand (R_{CP})), Generation of photocarriers by the same CP pulses is suppressed due to Pauli exclusion principle, while that by anti-CP pulse pairs is not. To measure the difference, polarization of each CP pulses were modulated between L_{CP} and R_{CP} using ultrafast pockels cells and l/4 waveplates. The difference in photocarrier densities between the two conditions was obtained from change in the reflectivity of sample ΔR (OPPR) or change in photo-induced tunneling current ΔI (TR-STM) by CP modulation. To avoid a modulation of optical intensity due to polarization change impinging ΔI signal through thermal effect, CP modulation was carried out in rectangular form at 1 MHz, while the relative phase of polarization between pulse pair was linearly modulated at 1 kHz. ΔI were measured as a function of delay time between pulse pair and plotted in fig.2. By fitting both spectra with exponential function, similar lifetime ~10ps has been obtained which is well corresponding to electron lifetime of undoped GaAs. Details of the method and experimental results will be discussed in the session.

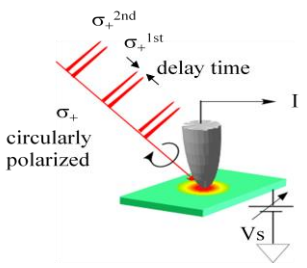

Fig.1 Schematic of time-resolved STM

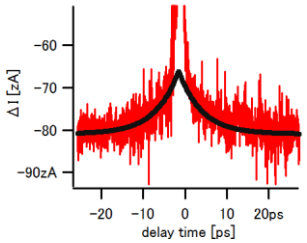

Fig.2 TR-STM spectra obtained for an undoped GaAs. Peak at 0 delay is due to interference between laser pulses.