Development of non-destructive local electrical conductivity measurement by using a multi-probe STM

T. Bamba,[1] H. Mogi[1], I. Kuroda[1], A. Taninaka[1] S. Yoshida[1], O. Takeuchi[1], and H. Shigekawa[1]
[1]Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan.

Recently, miniaturization of electronic devices has been steadily progressing. As the miniaturization progresses, local carrier scattering due to the nanoscale structure (i.e. defects, steps...) affects considerably on the device performances. We have developed a new measuring system based on the scanning tunneling microscope (STM) and measured the local conductivity on nanoscale. By using a single probe STM, the local electrical characteristics can be measured through the vertical tunneling contact. By using multi-probe STM, it is possible to measure the lateral electrical characteristics between the probes.

Fig. 1 shows a schematic of four-probe method in this experiment. Tip1, which is in tunneling contact, is electrochemically etched tungsten tip for STM. Tip2, Tip3 and Tip4, which are in mechanical contact, are a Pt/Ir coated conductive cantilevers for AFM. Tip1 probes the surface structure and the surface potential difference between Tip2 and oneself. The constant current is applied from Tip3 to Tip4.

In our previous studies, stiff probes for STM were used for the current applying probes, where the measurements suffered from probe/sample destruction and deformation due to hard contact. In this study, we replaced them with the AFM cantilevers, which allowed us to control the contact pressure more precisely, to avoid the deformation of probes or sample, and to bring the deformation-free current probe closer.

Fig. 2 shows the measurement concept. During STM topography measurement, scanning is interrupted on the grid points and measurement mode is switched between the current measurement mode (STM) and the potential measurement mode (STP). In this study, the sample was a sheet of ~10 μm thick graphite. Potential gradient in parallel to the bias current was confirmed with a few tens of microvolt resolution on the topographic image. Details will be reported on the presentation.

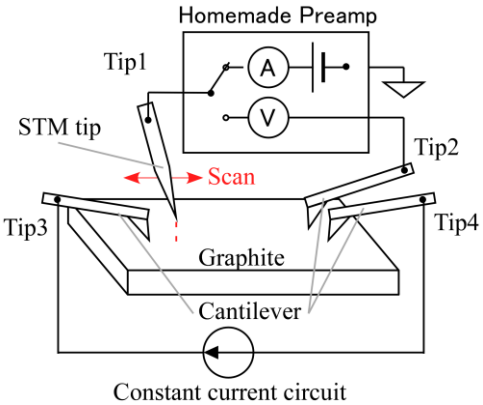

Fig. 1 Schematic of four-probe method

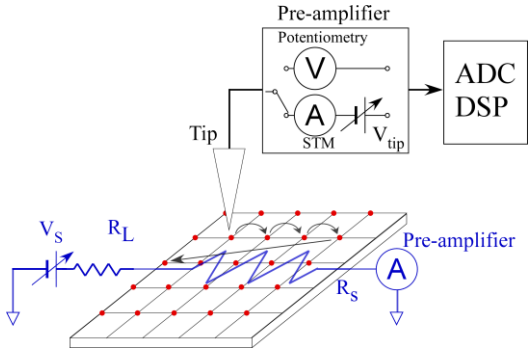

Fig. 2 Measurement concept of STM and STP