Local resistivity measurement by multiprobe scanning tunneling potentiometry

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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. Conventionally, the conductivity measurement have been done by four-terminal method with fabricating electrodes and forming a hall bar device. However, in such a macroscopic measurement, it is difficult to estimate how nanoscale structures affect to overall conductance. 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.

In this report, we performed four-probe measurement method including a tunneling junction with UHV four-probe STM (Unisoku Co., Ltd.) which is integrated with optical zoom lens (VH-Z100T, WD=24mm, Keyence Co., Ltd.). We use one stiff probe, which is in tunneling contact, is electrochemically etched tungsten tip for STM (Tip1). The other three probes, which are in mechanical contact, are a Pt/Ir coated conductive cantilevers for making soft contacts (Tip2, 3 and 4). 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.

The potential mapping could be distributed on the STM topography image as below. During STM topography measurement, scanning is interrupted on the grid points on the image 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 ~2 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.