Nanoscale Electrical Measurements with Quadruple-probe Atomic Force Microscope

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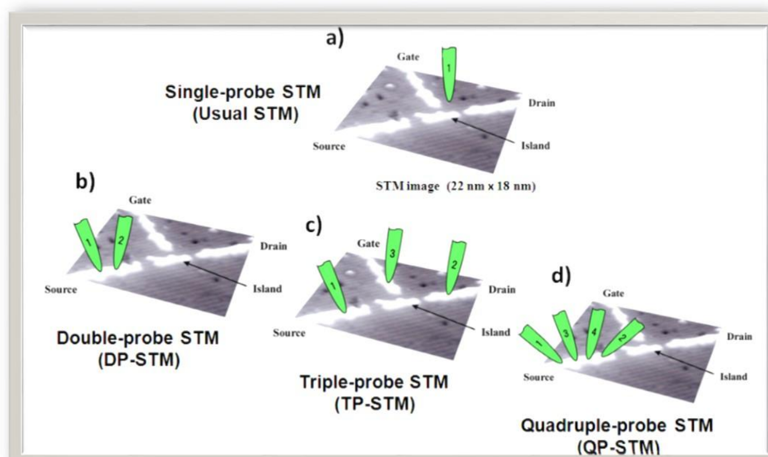
Abstract

Electrical property measurements of nanoscale materials and structures are highly demanded in understanding fundamental physics and functionalities of them. So far, such measurements have been done with a variety of ways including our multiple-probe scanning probe microscopes (MP-SPMs) [1,2]. As we know, scanning probe microscopes (SPMs) have been widely used for investigating structures and properties of nanoscale structures and materials. It is, however, difficult to directly reveal conductance of a nanomaterial though SPM reveals local densities of states around E_F. Then, we developed MP-SPM to bring independently-controlled multiple SPM probes into a nanoscale region with keeping original functions of SPM probes, which realizes unique and novel measurements in nanoscale.

Required number and types of MP-SPM probes when evaluating nanoscale electrical properties of individual nanostructures should be decided depending on the purpose of measurements (see Figure). In order to measure resistance of nanowires with a size inaccessible by SEM, we used two scanning tunneling microscope (STM) probes and positioned them on a single nanowire. Although the substrate must be conductive in this case, we could well separate a current flowing though the nanowire from that flowing through substrate, namely, leakage current. When non-conductive substrates must be handled, we use specially designed tuning fork type force sensors [3] and operate MP-SPM as a multiple-probe atomic force microscope. We show and discuss about recent nanoscale measurements done by MP-AFM on different materials, such as self-organized metal-silicide nanowires, graphenes, and carbon nanotubes.



References

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