Scanning tunneling microscope potentiometry on single layer graphene flakes

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Recently, low-dimension conductive materials such as nanowires, nanotubes and nanosheets are diligently studied as next-generation materials. Especially, carbon materials are well known with their excellent electrical and mechanical properties. Carbon nanotube field effect transistor, graphene transistor, etc., are expected to exceed the Si devices. It is important to investigate electrical conductance and charge transport property in nanoscale carbon objects.

For this purpose, we developed a multi-probe scanning tunneling microscope (STM) that can measure both scanning tunneling potentiometry and spectroscopy. With the microscope, we make surface potential measurements using their probes without contacting the sample but over a tunnel gap, the stray capacitance of the electrical circuit including the cables that connect the probes to the preamplifiers, in addition to the large tunnel resistance, forms a low pass filter, with which the measurement bandwidth becomes very narrow. We successfully expanded the bandwidth by developed preamplifier that compensates the stray capacitance.

Figure 1 shows the four probes measurement on a single layer graphene, which transcribed from a Cu substrate onto a SiO_2 layer grown on a Si substrate. Tip2 and Tip4 flow current (~40 μA) into graphene. We carried out STM potentiometry on red cross marks in Fig.1 with Tip3 that is in a tunneling contact against the reference probe of Tip1 that is fixed at the imaged position. Result is shown in Fig.2. Measured 1D resistivity was ~70 Ω/μm. We will discuss the key techniques for STM potentiometry with a tunnel contact and the physical origin of the rather high resistivity of the measured graphene islands.

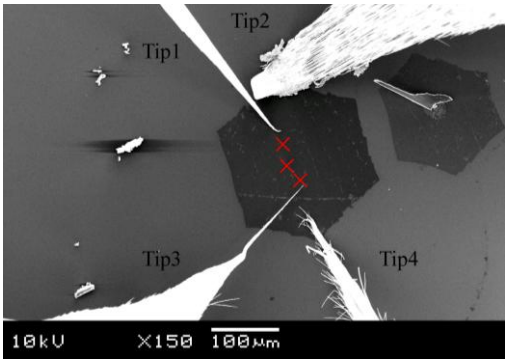

Fig. 1 . Graphene SEM image

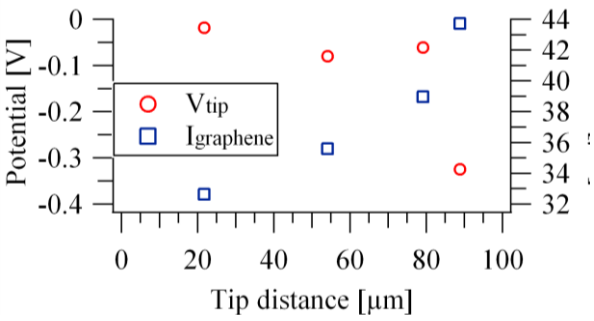

Fig. 2 . Potentiometry on graphene