Two-probe scanning tunneling spectroscopy as a tool for studing quantum transport at the atomic-level

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Techniques based on multiprobe scanning tunneling microscopy (MP-STM) allow determination of charge and spin transport in variety of systems supported on surfaces of solid materials. In classical 2- and 4-probe methods STM tips are navigated by scanning electron microscope or high-resolution optical microscope typically in micrometer scales down to hundreds of nanometers. These MP-STM methods are currently regarded as universal tools for in-situ characterization of mesoscopic transport phenomena [1,2].

Such a mesoscopic experimental paradigm has recently been changed by downscaling of 2-probe STM experiments towards the atomic level [3,4]. In this case current source and drain probes are positioned in atomically defined locations with respect to the characterized nanosystems. These experiments rely on fully STM-based tip positioning protocol with probe-to-probe separation distances reaching tens of nm [3,4]. Such probe-to-probe lateral positioning precision is combined with pm vertical sensitivity in establishing probe-to-system contacts. These two factors enable realization of two-probe scanning tunneling spectroscopy (2P-STS) experiments, where transport properties can be characterized by macroscopic probes kept in well-defined tunneling conditions [4].

Here, on chosen examples, I will present application of 2P-STS methodology. First, I will show that 2P-STS can give information about quasi-ballistic (coherent) transport through one-dimensional π^* states of germanium dimer row wires [4]. Then, I will discuss 2P-STS methodology to probe quantum transport properties in a functional system: graphene nanoribbons (GNRs) epitaxially grown on the sidewalls of silicon carbide (SiC) mesa structures. These GNRs display ballistic transport channels with exceptionally long mean free paths and spin-polarized transport properties as proven by mesoscopic multiprobe transport experiments [5-7]. Interestingly, the nature of the ballistic channels remains an open question. I will show that 2P-STS experiments can give a new insight into quantum origin of these transport properties. Finally, I will discuss perspectives for broader application of multiprobe STM/STS.

References

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