ROOM-TEMPERATURE FUNCTIONAL NANOELECTRONIC DEVICES AND CIRCUITS WITH BALLISTIC JUNCTIONS

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Present digital logic gates are primarily built from field effect transistors (FETs) such as complementary metal oxide semiconductors with the gate length in the deep sub-µm regime. As device feature sizes approach the nanometer regime, fundamental physical constraints and increasingly prohibitive economic costs will make further miniaturization in electronic circuits difficult, and this has motivated efforts worldwide to search for new strategies to meet expected computing demands of the future. In the strategy for device fabrication, bottom-up approaches to electronic devices with well-defined nanoscale building blocks have been demonstrated. An alternative strategy is to develop new device concepts by making a revolutionary departure from the FET-based paradigm. The approach must exploit the emerging inherent properties of nanostructures. Here we report on a paradigm based on multi-terminal ballistic junctions (MBJs), in which the ballistic nature of electron transport, which has emerged in the nanostructures, is exploited.

A MBJ is a nanostructure-compatible device formed from three or more ballistically coupled nonlinear conductors, such as quantum point contacts realizable by standard nanofabrication methods. A key requirement in the realization of this device is that carrier transport in the device is ballistic or quasi-ballistic. Various MBJ structures have been fabricated on high-quality semiconductor heterostructures and novel properties of MBJs have been found [1-6]. In particular, we demonstrate that MBJs can be used as diodes and triodes, as well as a building block for logic circuits. These devices function at room temperature, and the device layout features fabrication by a single-step lithography process that is suitable for mass production with low-cost approaches such as nanoimprint lithography. Furthermore, the demonstrated device principles are expected to apply equally well to multi-terminal junctions made from, e.g., molecules and nanotubes.

References:

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