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Modeling of a Resonant Tunneling Transistor under Uniaxial Strain

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Graphene is an atomically thin two-dimensional (2-D) crystal with unique thermal, mechanical, and electronic transport properties such as the high mobility of carriers, perfect 2-D confinement, and linear dispersion, etc., has been attracted many interests as a promising candidate for nano-scale devices over the past decades. Multilayer stacks of graphene and other stable, atomically thin, 2-D materials offer the prospect of creating a new class of heterostructure materials. Hexagonal boron- nitride (hBN), is a great candidate to be stacked with graphene due to an atomically 2-D layered structure with a lattice constant very similar to graphene (1.8% mismatch), large electrical band gap (~ 4.7eV), and excellent thermal and chemical stability. The graphene/hBN based tunneling transistors show the resonant tunneling and strong negative differential resistance (NDR). These devices which have the potential for future high-frequency and logic applications such as high-speed IC circuits, signal generators, data storage, etc., has been studied both theoretically and experimentally recently.

The aim of this paper has been to study the effect of the uniaxial strain on the graphene nanoribbon resonant tunneling transistors (RTTs). The uniaxial strain may be induced either by an external stress applied to the graphene in a particular direction or by a substrate due to deposition of graphene on top of the other materials. The strain modifies distances between carbon atoms which leading to different hopping amplitudes among neighboring sites.

A resonant tunneling transistor consisting of armchair graphene nanoribbon (AGNR) electrodes with three layers of hBN tunnel barrier between them has been considered. By using the nearest-neighbor tight-bind (TB) method and the nonequilibrium Green function (NEGF) formalism, the electronic transport characteristics of RTT is calculated. In this work, we focus on how the strain affects the current-voltage characteristics of AGNR/hBN RTT.

The results demonstrated that the strain decreased the amount of the current in both cases; however, the quantitative behavior of the I-V plot turned out to be different for the strain in different directions. The current collapsed more rapidly when the strain was applied in the armchair direction.

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