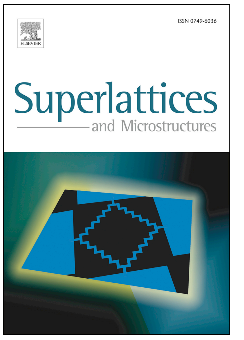
Accepted Manuscript



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PII: S0749-6036(17)31574-4

DOI: 10.1016/j.spmi.2017.11.027

Reference: YSPMI 5362

To appear in: *Superlattices and Microstructures*

Received Date: 29 June 2017

Accepted Date: 19 November 2017

Asymmetrical external effects on transmission, conductance and giant tunneling magnetoresistance in silicene

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Abstract

Electron transport in a silicene structure, composed of a pair of magnetic gates, is studied in a ferromagnetic and antiferromagnetic configuration. The transport properties are investigated for asymmetrical external effects like an electrostatic potential, a magnetic field and for asymmetrical geometric structure. This theoretical study, has been done using the matrix transfer method to calculate the transmission, the conductance for parallel and antiparallel magnetic alignment and the tunneling magnetoresistance (TMR). In Particular, we have found that the transmission, conductance and magnetoresistance oscillate as a function of the width of barriers. It is also found that a best control and high values of TMR spectrum are achieved by an asymmetrical application of the contact voltage. Besides, we have shown that the TMR is enhanced several orders of magnitude by the combined asymmetrical magnetization effect with an adequate applied electrostatic potential. Whereby, the asymmetrical external effects play an important role to improve TMR than symmetrical ones. Finally, the giant TMR can be flexibly modulated by incident energy and a specific asymmetrical application of control voltage. These results could be useful to design filters and digital nanodevices.

Keywords: Tunneling magnetoresistance; Silicene; Asymmetrical effects; Conductance; Electron transport

PACS: XXX

1. Introduction

Silicene is a monolayer of silicon atoms, forming a 2D dimensional honeycomb lattice [1, 2, 3, 4]. This new material has attracted more attention due to its tremendous application in nanoelectronics and for its special physical properties similar to those of graphene [5, 6, 7, 8]. In contrast to graphene, silicene has a large intrinsic spin-orbit interaction and a buckled structure involving valley and spin manipulation [9, 10, 11, 12, 13]. Recently, monolayer and multilayer silicene have been synthesized onto metallic substrates as well as a field effect transistor at room temperature reported [6, 14].

On the other hand, magnetic fields effects on nanostructures have been proposed to confine massless two-dimensional (2D) Dirac electrons [15, 16, 17] as well as a possible route to manipulate electron transport. For instance, Zai and Chang [15] have investigated the spin tunneling magnetoresistance effect in monolayer graphene modulated by two parallel stripes. They found a large TMR ratio of parallel to antiparallel configuration of magnetization and that this ratio can be tuned by the inclusion of an electric field. Likewise, Wang et al. [18] have explored magnetotransport (specifically TMR) in graphene with two tunable magnetic barriers. They have shown that TMR is sensitive to distance between the magnetic barriers. More interestingly, they reported that with asymmetrical barriers, barriers with different height, TMR enhances an order of magnitude with respect to the symmetrical case.

Under this context, silicene is an ideal material to manipulate spin transport due to its intrinsic large spin-orbit coupling. In fact, the scientific community has been committed to improve and control the spin transport properties, particularly magnetoresistance (MR) and TMR [5, 19, 20, 21, 22, 23, 24, 25,