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Review

Review on graphene spintronic, new land for discovery

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ABSTRACT

The science for processing and control of electron spins is referred to as "Spintronics". Metals, semiconductors, and in particular carbon-based materials are especially interesting in this respect due to their spin arrangements. Graphene, a hexagonal two-dimensional structure of carbon has attracted much attention due to its spin relaxation mechanism and many other advantages. We discuss the origin of graphene's spin in nano-scale devices. A key concept for understanding spin polarized state properties of graphene is Lieb's theorem, according to which one can predict whether a graphene structure is spin-polarized. However, this theorem cannot predict anything about magnetic properties of graphene. Lieb's theorem has many important consequences including spin polarization of a supercell, and that quasi-localized states populating complementary sublattices interact with each other. There exists a large number of theoretical works, which study graphene spin polarization using theoretical methods to investigate the magnetic properties of graphene. We will discuss these theoretical works and their important consequences. In addition, several key experimental results for graphene's spin Engineering are produced.

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Contents

1. Introduction

1.1. What is spintronics?

The possibility of using electron's spin rather than its charge to process, transfer and control signals has claimed exciting new horizons in science and technology. In what has come to be known as Spintronics, the spin will provide ultimate logic bit [1]. The concept should lead to higher data processing speeds, higher integration density, and higher energy efficiency [2].

Any electron moving under the influence of an external magnetic field introduces a specific spin polarization, which reverses when the external magnetic field reverses direction. There are two directions for spin polarization, defined as "spin up" and "spin down". By this concept, one can build a binary logic system by reading "spin up" and "spin down" as "1" and "0" states, respectively [3].

Consideration of the electron's spin as a bit of information is the key concept to operation of spintronic devices, and the magnetic field is the tool for managing the device state presenting the device state being bit '1' or '0'. An 'effective' field or a real magnetic field rotates the spin by 180°. None of the operations involving electron spin requires raising or lowering the barrier to charge motion. In addition, switching within current information-processing devices is carried out via the controlled motion of small pools of charge, whereas in the devices information storage, it is performed by reorienting magnetic domains (although charge motion is often used for the final stage of readout).

When electric current flows through a diffusive conductor, the current can be considered as two independent spin channels [4]; one is the spin up (↑) electrons, and the other one is the spin down (↓) electrons. Due to the scattering process, the coupling between these two channels may be strengthened. Then the two channels become correlated. The spin current density of spin up (down) is directly proportional to the gradient of the electrochemical potential. In a one-dimensional system, the spin current density is determined as [3]: