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Magnetic versus Non-Magnetic Adatoms in Graphene Nanoribbons: Tuning of Spintronic Applications and the Quantum Spin Hall Phase

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Abstract : Conductance in graphene nanoribbons (GNR) in presence of magnetic (for example, Iron) and non-magnetic (for example, Gold) adatoms are explored theoretically within a Kane-Mele model for their possible spintronic applications and topologically non-trivial properties. In our work, we have considered the magnetic adatoms to induce a Rashba spin-orbit coupling (RSOC) and an exchange bias field, while the non-magnetic ones induce an RSOC and an intrinsic spin-orbit (SO) coupling. Even though RSOC is present in both, they, however, represent very different physical situations, where the magnetic adatoms do not preserve the time reversal symmetry, while the non-magnetic case does. This has important implications on the topological properties. For example, the non-magnetic adatoms, for moderately strong values of SO, the GNR denotes a quantum spin Hall insulator as evident from a $2e^2/h$ plateau in the longitudinal conductance and presence of distinct conducting edge states with an insulating bulk. Since the edge states are protected by time reversal symmetry, the magnetic adatoms in GNR yield trivial insulators and do not possess any non-trivial topological property. However, they have greater utility than the non-magnetic adatoms from the point of view of spintronic applications. Owing to the broken spatial symmetry induced by the presence of adatoms of either type, all the x, y and z components of the spin-polarized conductance become non-zero (only the y-component survives in pristine Graphene owing to a mirror symmetry present there) and hence become suitable for spintronic applications. However, the values of the spin polarized conductances are at least two orders of magnitude larger in the case of magnetic adatoms than their non-magnetic counterpart, thereby ensuring more efficient spintronic applications. Further the applications are tunable by altering the adatom densities.

Keywords : magnetic and non-magnetic adatoms, quantum spin hall phase, spintronic applications, spin polarized conductance, time reversal symmetry
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