VOI-Based Valley Filter in Bilayer Graphene

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Abstract

The graphene band structure exhibits two-fold valley degeneracy at the Dirac points (K and K'), giving each graphene electron the binary degree of freedom known as valley pseudospin to realize valleytronics.[1]. Gapped graphene is particularly suited to such an application, because the breaking of AB sublattice symmetry leads to the existence of a finite pseudospin magnetic moment [2], and opens the door to an electrical manipulation of valley pseudospin through the mechanism of valley-orbit interaction (VOI) that occurs between the pseudospin and an in-plane electric field. Employing a unified VOI-based methodology, we have proposed a family of electrically-controlled valleytronic devices, including valley qubits and valley FETs.[2] Here, we report the theoretical study of a recently added member of the family - a valley filtering structure consisting of a Q1D channel in bilayer graphene, with the channel defined and controlled by electrical gates as shown in Figure 1, as well as the valley valve consisting of two of the proposed filters which can perform a two-way conversion between electrical and valleytronic signals as shown in Figure 2. We discuss two types of calculations – those of the Q1D energy subband structure in the channel of a filter and the electron transmission through a valley valve. For the former, we have developed a tight binding formulation in the continuum limit, which yields the energy subband structure shown in Figure 3 and the corresponding valley polarization of a subband state shown in Figure 4. For the calculation of electron transmission through a valley valve, we employ the recursive Green's function method, and consider two configurations of in-plane fields in the filters as shown in Figure 5, with the result shown in Figure 6 demonstrating the potential of the valve to function as an electrically controlled on-off switch. The results will be discussed in the presentation.

References

Figures

Figure 1

Figure 2
Figure 3

Figure 4

Figure 5

Figure 6