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

[1] Rycerz et al., Nat. Phys. **3** (2007),172.
[2] Xiao et al., Phys. Rev. Lett. **99**, (2007), 236809.
[3] Wu et al., Phys. Rev. **B 84**, (2011), 195463; ibid **B 86** (2012), 045456; ibid **B 86** (2012), 165411; ibid **B 88** (2013), 125422.

Figures

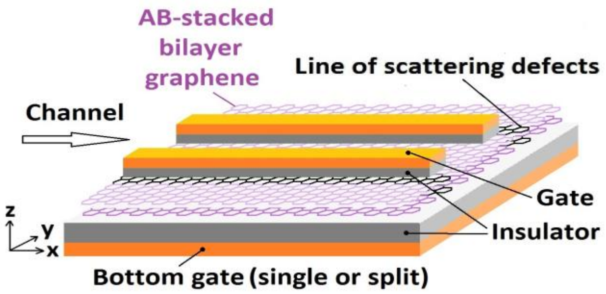

Figure 1

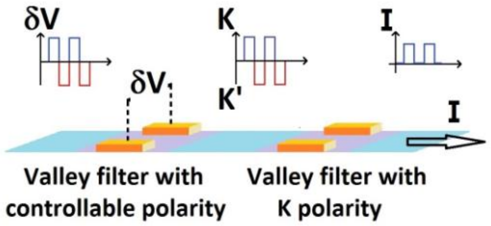

Figure 2

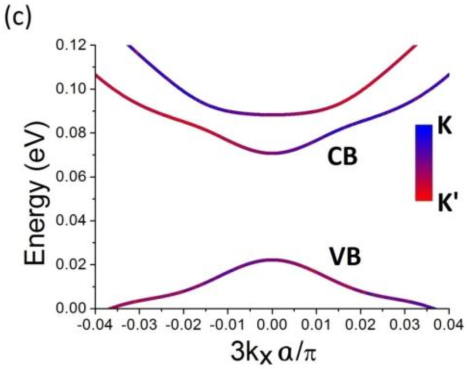

Figure 3

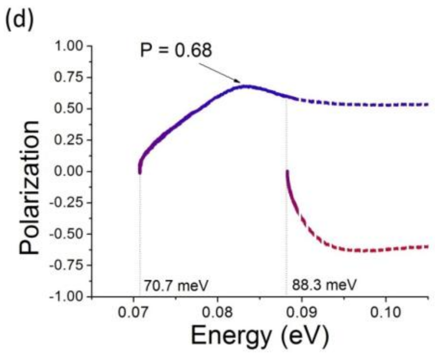

Figure 4

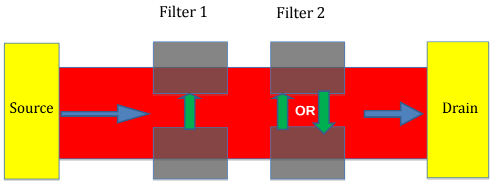

Figure 5

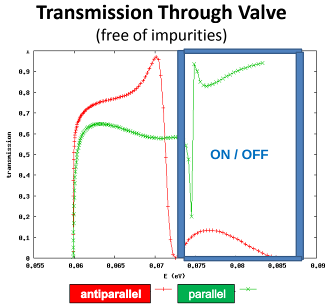

Figure 6