Valley and Spin Filter Using Multiple Magnetic Barriers on a TMDC Nanoribbon

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In the transition metal dichalcogenides nanoribbon with multiple magnetic barriers, the degeneracy of the K and K′ valley is broken owing to the valley Zeeman effect in the magnetic barrier region[1,2]. The energy band of the K′ valley does upward while that of the K valley goes down. Carriers move from source to drain, are affected differently by the magnetic barriers, depending on their valleys. The combination of the Fano resonance, the quantum interference between continuum states and Landau levels in the magnetic barriers, in K valley and resonance tunneling effects in K′ valley are the main ingredients of valley polarization. With the intrinsic spin orbit interaction of TMDC and the conventional Zeeman effect, the spin degeneracy of the energy bands at K and K′ are broken, which leads to spin polarization. These polarizations can be enhanced by increasing the number of magnetic barriers. Valley polarization occurs in the energy region that the resonance peaks of the K′ valley and the conductance suppression of the K valley are co-existed. For reversing valley polarization, any need for a change in the direction of the magnetic field is not necessary in this quantum system. Currents with arbitrary spin and valley degrees of freedom can be selectively obtained by manipulating an incident carrier energy with the optimized parameters of this system. An experimental realization of this system should make it possible to control the valley and spin degrees of freedom of carriers in future devices.

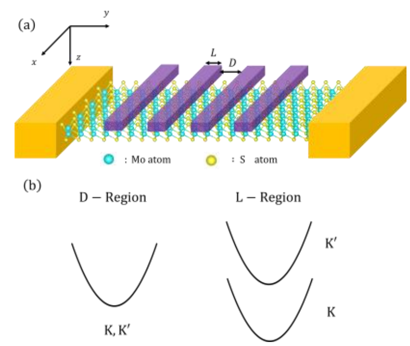

Fig.1. (a) Schematic geometry of MoS_2 with multiple magnetic barriers. The magnetic field is along the z direction. The width of the magnetic barriers and the distance between the two barriers are denoted by L and D, respectively. The cyan atoms are Mo and the yellow atoms are S. (b) Energy dispersion of the K and K′ valleys in nonmagnetic (D) and magnetic barrier (L) regions.

References

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