MAR11-2010-001154

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

Spin States, Spin Correlations, Supercurrent, and Multiple Andreev Reflections in InSb Nanowire Quantum Devices

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Bulk InSb is one of the most promising materials for applications in spintronics and quantum information processing, due to the fact that it has the highest electron mobility $\mu_e = 77000$ cm2/Vs, the smallest electron effective mass $m_e^* = 0.015$ me, and the largest electron magnetic moment $|g^*| = 51$ among all III-V semiconductors. Here, we report on realization and electrical measurements of InSb quantum dots and superconductor/InSb/superconductor hybrid quantum devices. The devices are made on a SiO2-capped Si substrate from InSb segments of InAs/InSb heterostructured nanowires grown by metal-organic vapor phase epitaxy. Spin states, effective g-factors, and spin-orbit interaction energy are measured for the fabricated InSb nanowire quantum dots [1]. We have also studied strong correlation phenomena and observed a new spin-correlation-induced phenomenon in the devices, namely the conductance blockade at the degeneracy of two orbital states with the same spin [2]. We attribute this conductance blockade to the effect of electron interference between two equivalent, strongly correlated, many-body states in the quantum dots. In superconductor/InSb nanowire/superconductor hybrid devices, we have observed supercurrent and multiple Andreev reflections, and have found that the fluctuations in the supercurrent are correlated to the conductance fluctuations of the corresponding InSb nanowires in the normal state. We have also observed multiple Andreev reflections and interplay between the Kondo correlation and proximity effect in the Coulomb blockade regime.

[1] H. A. Nilsson et al., Nano Lett. 9, 3151-3156 (2009).
[2] H. A. Nilsson et al., Phys. Rev. Lett. 104, 186804 (2010).