MAGNETO-NOISE IN CARBON NANOTUBE FIELD EFFECT TRANSISTOR

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Introduction

The noises and charge fluctuations are two pronounced issues in the nanodevices. One kind of the charge fluctuations of particular interest is random telegraph signal (RTS). It is interesting to study the spin characteristics of individual defects using RTSs in nanodevices.

Experimental

Measure the current and conductance fluctuations as a function of device bias and magnetic field using He3 superconducting magnet provided by NHMFL.

Results and Discussion

Figure 1 (a) shows the magneto- RTS behavior at the temperature of 0.32K with the voltage biases of Vg=-7.5V and Vds=-0.5V. The emission and capture time constants showed almost no magnetic dependence (the time constant variation is less than 10%) with magnetic field up to 18T for both magnetic field directions and over a wide temperature range from 0.32K to 24K. Figure 1 (b) plots the statistics of the RTS time constants at the temperature of 0.32K. The emission and capture time constants remain almost constant within the range of measurement error, indicating no longitudinal magnetic field dependence of the RTS for the entire gate bias range. Furthermore, the time constants also show no transverse magnetic field dependence for T=24K as plotted in Fig. 1 (c). Similar experiments were also preformed for more than 15 devices with Coulomb repulsive RTSs and Coulomb attractive RTSs in p-type CNT-FETs under different gate and source-drain biases as well as at different sample temperatures. The absolute source-drain current increases with increasing magnetic field; and the switching amplitude of the RTSs increases roughly proportional to the increase of the source-drain current. This phenomenon becomes pronounced especially when the magnetic field is in parallel direction. However, the time constants of both Coulomb repulsive and Coulomb attractive RTSs show weak magnetic dependence. The lack of magnetic dependence for the RTSs may arise from the fact that spin relaxation for a hole is much faster than that for an electron. Hence, the extra spin-orbit interactions result in a fast spin relaxation time. Furthermore, the RTS defect center may come from ferromagnetic impurities like Fe used as catalyst during the CNT synthesis process. Hence, the Zeeman level broadening due to spin relaxation could be the reason for the lack of the magnetic dependence of the RTSs in CNT-FETs.

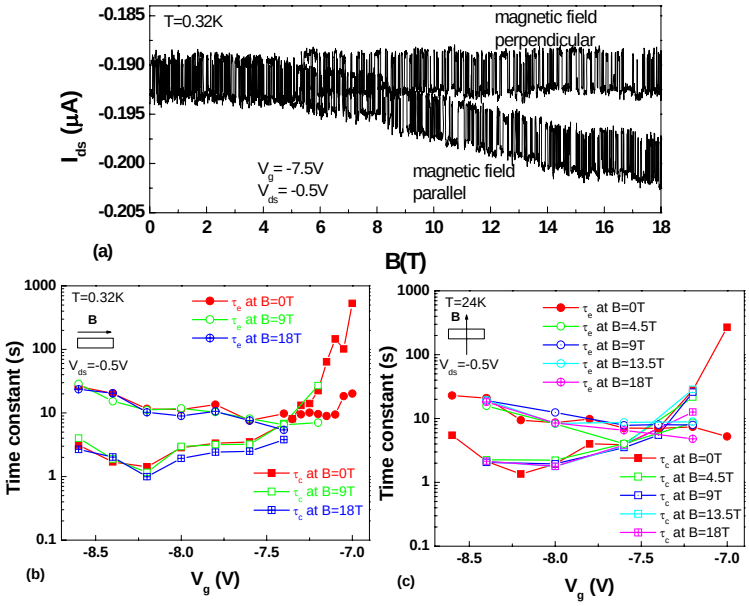

Fig. 1 (a) The RTS with the magnetic field from 0T to 18T in both perpendicular and parallel directions. (b) Emission and capture time constants (V_{ds}=-0.5V) at a temperature of 0.32K with parallel magnetic field of 0T, 9T, 18T. (c) Emission / capture time constants (V_{ds}=-0.5V) at a temperature of 24K with the perpendicular magnetic field of 0T, 4.5T, 9T, 13.5T and 18T.

Conclusions

Being different from the Coulomb repulsive RTS in the n-type MOSFETs, the RTS in the p-type CNT-FETs showed weak magnetic dependence, which may be due to fast spin relaxation time for hole defects.

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