Graphene and spintronics

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Several spintronic devices (logic gates, spin FET, etc) are based on spin transport in a lateral channel between spin polarized contacts. We will present, with experiments in support, an overall picture of the properties of carbon nanotubes and graphene for the transport of spin currents to long distance in such types of device. Their advantage over classical semiconductors and metals comes from the combination of their large electron velocity with their long spin life time due to the small spin-orbit coupling of carbon. This leads to spin diffusion lengths ≈ 100 μm.

For graphene, the experiments we present are magneto-transport measurements on graphene multilayers on SiC [1] connected to cobalt electrodes through alumina tunnel barriers. In terms of $\Delta R = \Delta V/I$, the spin signals, at low and room temperature, are in the MΩ range, well above the spin resistance of the graphene channel. The analysis of the results in the frame of drift/diffusion equations [2] leads to spin diffusion length in graphene around 100 μm for a series of samples having different lengths and different tunnel resistances . The advantage of the graphene is not only the long spin diffusion length. The large electron velocity also leads to short enough dwell times even for spin injection though tunnel barriers.

Our results on graphene can be compared with previous results [3] obtained by some of the authors (L.H., N.M., A. F.) on carbon nanotubes with also spin signals ΔR in the MΩ range (ΔR/R up to 72%) and spin diffusion lengths around 50 μm. A unified picture of spin transport in nanotubes and graphene will be presented.

In conclusion, carbon-based conductors like carbon nanotubes and graphene, with their combination of a long spin life time with a large electron velocity and the resulting long spin diffusion length, turns out as materials of choice for large scale logic circuits and the transport/processing of spin information. Understanding the mechanism of the spin relaxation, improving the spin diffusion length and also testing various concepts of spin gate are the next challenges.

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[3] L.E. Hueso, J.M. Pruneda, V. Ferrari, G. Burnell, J.P. Valdes-Herrera, B.D. Simons, P.B. Littlewood, E. Artacho, A. Fert, and N.D. Mathur, *Nature*, **445**, 410, 2007.