Large signal graphene spintronics

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In the quest for large signal spintronics, graphitic compounds were already demonstrated as a successful alternative to inorganic semiconductors: long spin diffusion length (50 µm) and large spin signals (80 MΩ) have been achieved for carbon nanotubes [1]. This result awaits now to be extended to wafer scale materials like epitaxial graphene. The high mobility of graphene (up to $10^7 cm^2/Vs$) [2,3] combined with the long predicted spin life-time make it a very promising material for spintronics devices: the spin diffusion length is expected to exceed 100 µm. Successful spin dependent transport has already been demonstrated in micron-sized exfoliated graphene sheets [4,5], with reported spin-diffusion length in the order of 1-4 µm and spin signal of few hundred ohms, more than 4 orders of magnitude lower than for nanotubes. Taking advantage of the full potential of graphene for spintronics will therefore require material and device optimization.

Working on spin injection, transport and detection in graphene, we focused first on the physics involved at the injection. It has been shown since 2000 [6,7] that an interfacial resistance is crucial for efficient spin injection in a semiconductor channel. The most common and efficient tunnel barriers used in the field of spintronics are sputtered Al_2O_3 and MgO. Hence, we chose to study the growth on graphene of these high quality tunnel barriers with thicknesses tuned for efficient spin injection and detection with graphene. To grow 1nm thick layer of Al_2O_3, we first deposit a 0.6nm Al film, and then oxidize it in a pure O_2 atmosphere. In the case of MgO, we directly deposit a 1nm film from a sintered MgO target.

We will present a Raman spectroscopy study quantifying the impact of the barriers growths on the graphene structure followed by spin-dependent transport measurements. Raman spectroscopy point to dramatic effect of sputtered MgO compared to Al_2O_3. When one wants to make use of standard tunnel junctions, Al_2O_3 is shown as definitely more suitable for spin transport together with bilayers (and other multilayers) graphene. The electrical characterization of these Al_2O_3 tunnel barriers reveals their adequacy in order to access high spin signals.

We carried transport measurements on lateral spin valves (Fig. 1.) in exfoliated graphene as well as in epitaxial graphene on SiC. We achieved spin signals in the MΩ range in two terminal geometries. These signals analyzed through an adapted injection/detection model [7] points to a long spin diffusion length in our systems.

References

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