Tunable magnetic contacts and their role in graphene spintronics

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Abstract

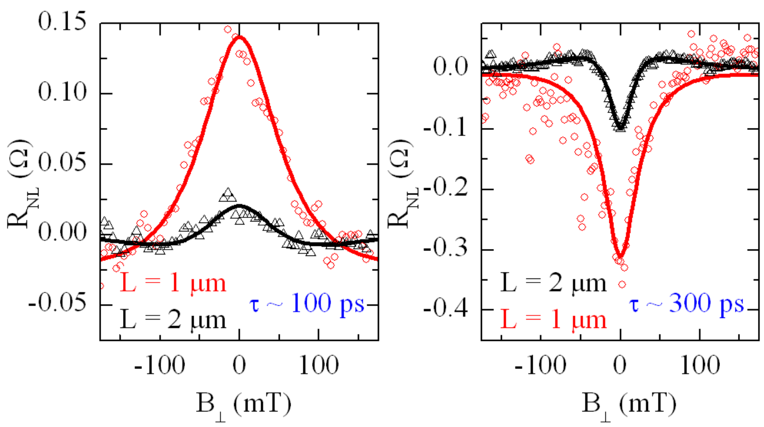
Graphene has proved to be an ideal system to study spin transport. However, graphene spintronic devices show spin relaxation lengths of up to a few micrometers at room temperature, orders of magnitude lower than theoretical predictions. Several works attribute this observation to the "conductivity mismatch" problem, where the difference between the spin resistance of the magnetic contact and the graphene channel causes injected spins to be backscattered into the contacts and therefore lose their spin information. A way to reduce this backscattering is by inserting an oxide barrier between the magnetic electrode and the graphene channel, resulting in highly resistive tunnel contacts. Here we approach this problem, both experimentally [1] and theoretically [2], in order to understand the experimental factors limiting the spin relaxation time in graphene.

Our experimental approach focuses on harnessing the tunability of the magnetic contacts which control electrical spin injection and detection in graphene [1]. For this purpose we developed contacts where the oxidation state of the oxide barrier can be controlled by annealing or by electroforming. Both approaches result in tuning of the transport properties of the contacts via an increased contact resistance, appearance of tunneling behavior and even sign reversal of their spin polarization. This simple approach allows us to explore the graphene spin transport properties both with and without the conductivity mismatch problem within the same device. We also studied how nonlocal Hanle precession measurements are affected by the contact-induced spin relaxation via a spin transport model [2]. The model accounts for changes in the Hanle line shape due to the finite contact resistances and quantifies how it modifies the extracted spin transport properties. The combination of experiment and modeling allows us to conclude that the conductivity mismatch problem is not the limiting mechanism in the present experimental studies. Therefore we raise the need to uncover other sources of spin relaxation in graphene.

References

[1] I. J. Vera-Marun, P. J. Zomer, M. H. D. Guimarães, M. Wojtaszek, and B. J. van Wees, to be submitted.
[2] T. Maassen, I. J. Vera-Marun, M. H. D. Guimarães, and B. J. van Wees, Phys. Rev. B, **86** (2012) 235408.

Figures



Nonlocal Hanle precession in bilayer graphene, both before (left) and after (right) annealing. After annealing, we observe a threefold increase in the spin relaxation time and a sign reversal of the spin signals.