Graphene Spintronics

Mini-colloquium 03

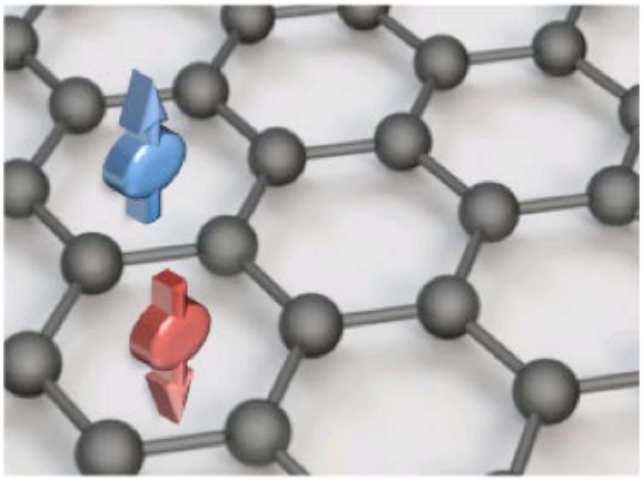
Jaroslav Fabian
Institute for Theoretical Physics
University of Regensburg
93040 Regensburg, Germany

jaroslav.fabian@ur.de

Stehan Roche
Institut Catala de Nanociencia i Nanotecnologia (ICN2)
Campus de la UAB, Edifici ICN2
08193 Bellaterra (Barcelona)
Spain
stephan.roche@icn.cat

Pierre Seneor
Unite Mixte de Physique CNRS/Thales (UMR137)
1 Avenue A. Fresnel
91767 Palaiseau Cedex
France
pierre.seneor@thalesgroup.com

Keywords: spin injection, spin relaxation, magnetism, spin-orbit coupling



Graphene is an ideal material for spintronics [1]. It has small spin-orbit coupling, weak hyperfine coupling coming from its nuclear spin isotope, and high mobility to keep the electron spins coherent over microns, enough to build spintronic devices and platforms for spin based quantum computing. Graphene could also be a host of ferromagnetic ordering coming from specific adatoms and substrates, opening new venues for molecular-size magnetic storage. The field of graphene spintronics has generated great knowledge in the past years, following the successful electrical spin injection [2], unveiling its potential as a platform for spintronics [3]. The last one-two years have seen remarkable developments which are the focus of this mini colloquium. Light adatoms and vacancies have been demonstrated [4] to induce magnetic moments and lead to resonant scattering of electrons. The spin Hall effect has been observed in hydrogenated graphene [5], proving colossal induced spin-orbit coupling by hydrogen adatoms. Graphene has also been shown to have high potential as a spin injection barrier [6]. Further progress in understanding spin transport in engineered graphene structures has been made [7] . Nevertheless, there are still many unresolved fundamental

issues, which will also be addressed. These issues include the role of the electrodes in spin injection, the (various) mechanisms behind spin relaxation, or the underlying formation of magnetic moment induced by adatoms or magnetic materials [8], the possible long range magnetic state created by sublattice segregation, and their corresponding impact on magnetoresistance signals and spin propagation features.

References

[1] I. Zutic, J. Fabian, S. Das Sarma, Rev. Mod. Phys. 76, 323 (2004).

[2] N. Tombros, C. Jozsa, M. Popinciuc, H. T. Jonkman, and B. J. van Wees, Nature 448, 571 (2007).

[3] B. Dlubak, M. B. Martin, C Deranlot, B. Servet, S. Xavier, R. Mattana, M. Sprinkle, C. Berger, W. De Heer, F. Petroff, A. Anane, P. Seneor, A. Fert, Nature Physics, 8, 557 (2012).

[4] K. M. McCreary, A. G. Swartz, W. Han, J. Fabian, and R. K. Kawakami, Phys. Rev. Lett. 109, 186604 (2012).

[5] J. Balakrishnan, G. KokWai Koon, M. Jaiswal, A. H. Castro Neto, and B. Özyilmaz, Nature Physics 9, 284 (2013).

[6] O. M. J. van 't Erve, A. L. Friedman, E. Cobas, C. H. Li, J. T. Robinson and B. T. Jonker Nature Nanotechnology 7, 737 (2012).

[7] F. Volmer, M. Drögeler, E. Maynicke, N. von den Driesch, M. L. Boschen, G. Güntherodt, and B. Beschoten, Phys. Rev. B 88, 161405 (2013).

[8] H. X. Yang, A. Hallal, D. Terrade, X. Waintal, S. Roche, and M. Chshiev, Physical Review Letters, 110, 046603 (2013).