Spin lifetime of electrons in graphene increased by magnetic fields

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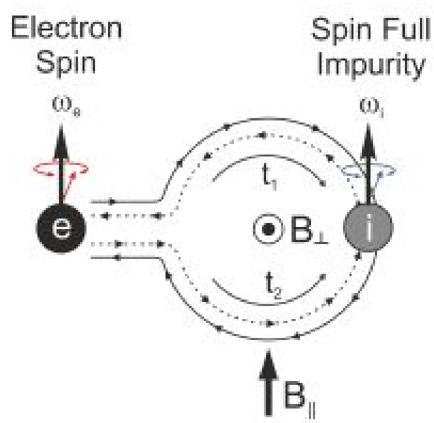


Researchers at Chalmers University of Technology shows that applying a moderate in-plane magnetic field increases spin lifetime of electrons in graphene. The results of this work have profound implications for graphene's use as post-CMOS platform in spintronics, and make an important contribution to the understanding of physics of 2D materials. The findings have recently been published in the prestigious journal *Physical Review Letters*.

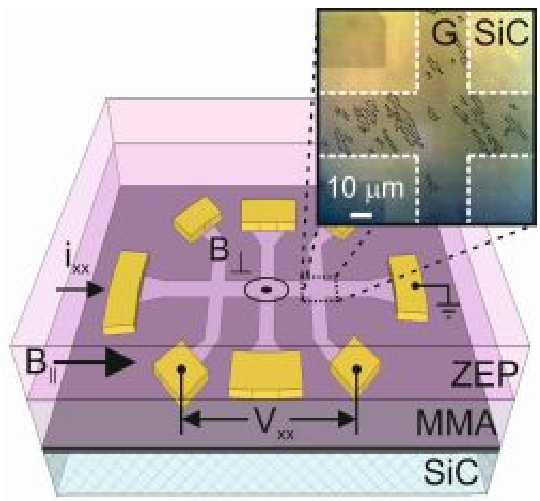
"With this work we have contributed to adding a piece to the puzzle of why graphene is in practice not as good for spintronics a theory predicts.

We must continue finding other pieces of this interesting puzzle" says Sergey Kubatkin, professor in quantum device physics, at Chalmers.

Graphene is one of the promising candidates in post CMOS platform for spintronics, the use of electron spin for information processing. One practical requirement for spintronics is to find materials in which the electron spin can travel for long distances without disturbances, that is, materials with long spin lifetime. In theory, graphene is an ideal material for this due to its high carrier mobility and capability to maintain the electron spin intact for milliseconds. However, in real graphene the spin lifetime is in the order of nanoseconds, that is, a discrepancy between theory and experiment of about 6 orders of magnitude.

What limits the spin lifetime in real graphene devices? That is the question addressed by the study and currently one of the main puzzles in graphene physics. In a previous publication in the same journal, published in October 2011 (see link below), the group put forward the idea that the spin lifetime in graphene may be limited by scattering on defects in graphene, which behave as magnetic impurities. Now the team has proven this idea directly by applying a moderate in-plane magnetic field and observed an increase on electron spin lifetime: the in-plane magnetic field freezes the magnetic defects, and the disturbances to electron spin in graphene are suppressed.

To investigate these effects, researchers measured electron spin relaxation via quantum interference corrections to electrical conductivity of graphene at low temperatures. This quantum correction is destroyed by weak perpendicular magnetic fields and by the randomising effect of temperature, however it is experimentally seen to stay finite even at the lowest temperatures. Unexpectedly, the influence of the in-plane field on spin lifetime was non-monotonic: a very weak in-plane field has resulted in a small but noticeable decrease in spin lifetime before it was enhanced in a somewhat stronger field. The behaviour in the weak field was understood in terms of a previously unknown spin dynamics contribution to magnetotransport: the in-plane field forces precession of both the electron spin and the magnetic defect spin. If the two rotate at the same rate and in the same direction, precession makes no effect on electron spin lifetime. However, if electrons "see" the spin of scattering impurities at random phase, the electron's spin lifetime decreases.



More information: "Influence of Impurity Spin Dynamics on Quantum Transport in Epitaxial Graphene." *Phys. Rev. Lett.* 115, 106602 (2015). dx.doi.org/10.1103/PhysRevLett.115.106602

"Disordered Fermi Liquid in Epitaxial Graphene from Quantum Transport Measurements." *Phys. Rev. Lett.* 107, 166602 (2011). dx.doi.org/10.1103/PhysRevLett.107.166602

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