Spin transport in high mobility graphene devices

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There is a large interest in high mobility graphene devices and the methods to fabricate heterostructures using graphene and hexagonal boron nitride (hBN) continue to improve [1]. Here we present a very recent development that allows for building stacks by picking up the respective crystals one by one from a substrate yielding excellent charge transport without the need for time consuming cleaning steps [2]. We then employ this method to take the next step in high mobility graphene spintronics [3].

In spintronics, an electrons spin degree of freedom is used to carry information. In order to reduce loss of this information and carry it over larger distances, a medium that preserves the spin orientation is required. Graphene promises to be an excellent candidate for this purpose; very large spin relaxation times are expected due to small spin orbit coupling and hyperfine interaction. Indeed, experimental work demonstrated graphene's potential for room temperature spintronics already in 2007 [4]. Typically spin relaxation times τ in the order of 100 ps and lengths λ of ~2 µm are obtained for graphene on SiO_2.

Although the potential of graphene for spintronics has been demonstrated, the theoretical expectations were set considerably higher, predicting relaxation times of hundreds of nanoseconds [5]. Two main mechanisms for spin relaxation in graphene are distinguished: the Elliott-Yafet and the D'Yakonov-Perel mechanism, with τ respectively depending linearly and inversely on the momentum scattering time. In order to build a better understanding of the spin relaxation mechanism in graphene we therefore investigate spin transport in high mobility devices. Two approaches are taken to this end; graphene is either suspended [6] or based on hBN [3,7], increasing the charge carrier mobility by at least one order of magnitude with respect to SiO_2 based devices.

For hBN based spintronic devices we could achieve spin transport over record lengths of 20 µm, yet τ remained relatively unaffected with values ranging between 50 and 500 ps and $\lambda \approx 4.5$ µm [7]. A drawback for the hBN based geometry is that polymer remains that negatively affect the device quality cannot be removed using a standard annealing step as this strongly degrades the ferromagnetic contacts. Therefore we now take an alternative route where we use our new method to encapsulate graphene with hBN and prevent further contamination during processing. Interestingly, this does lead to a clear increase of τ to 1.3 ns and λ to 12 µm at room temperature [3].

References

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