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Graphene: A membrane with steadily improving spin and charge transport properties

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Long electron spin lifetimes are an important prerequisite for enabling advanced spintronic devices. In this respect the 1-ns benchmark is of high technological interest as it marks the threshold at which manipulation of spins with electrical high frequency technology becomes feasible (1 ns $\leftrightarrow$ 1 GHz). For a long time, the measured spin lifetimes were shorter than 1 ns. Here we report on a major improvement in device fabrication which pushes the spin lifetimes to 12.6 ns in single layer graphene spin transport devices at room temperature which results in spin diffusion lengths as long as 30.5 μm [1]. This is accomplished by the fabrication of Co/MgO-electrodes on a Si/SiO_2 substrate and the subsequent dry transfer of a graphene/hexagonal boron nitride (hBN) stack on top of this electrode structure where a large hBN flake is needed in order to diminish the ingress of solvents along the hBN-to-substrate interface. We demonstrate that the spin lifetime does not depend on the contact resistance area products in these devices, indicating that spin absorption at the contacts is not the predominant source for spin dephasing which may pave the way towards probing intrinsic spin properties of graphene. In the second part, we summarize our effort to replace natural by synthetically grown graphene [2]. We report on an advanced transfer technique that allows both reusing the copper substrate of the CVD graphene growth process and making devices with carrier mobilities as high as 3,000,000 $cm^2/(Vs)$ for single layer graphene [3] and 180,000 $cm^2/(Vs)$ for bilayer graphene [4] thus rivaling exfoliated "natural" graphene. This material quality allows truly ballistic experiments with electron mean free paths exceeding 28 μm which brings novel electron-optic devices into reach.

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