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Homoepitaxial graphene tunnel barriers for spin transport

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Tunnel barriers are key elements for both charge-and spin-based electronics, offering devices with reduced power consumption and new paradigms for information processing. Such devices require mating dissimilar materials, raising issues of heteroepitaxy, interface stability, and electronic states that severely complicate fabrication and compromise performance. Graphene is the perfect tunnel barrier. It is an insulator out-of-plane, possesses a defect-free, linear habit, and is impervious to interdiffusion. Nonetheless, true tunneling between two stacked graphene layers is not possible in environmental conditions (magnetic field, temperature, etc.) usable for electronics applications. However, two stacked graphene layers can be decoupled using chemical functionalization. We demonstrate successful tunneling, charge, and spin transport with a fluorinated graphene tunnel barrier on a graphene channel. We show that while spin transport stops short of room temperature, spin polarization efficiency values are the highest of any graphene spin devices. We also demonstrate that hydrogenation of graphene can also be used to create a tunnel barrier. We begin with a four-layer stack of graphene and hydrogenate the top few layers to decouple them from the graphene transport channel beneath. We demonstrate successful tunneling by measuring non-linear IV curves and a weakly temperature dependent zero-bias resistance. We demonstrate lateral transport of spin currents in non-local spin-valve structures and determine spin lifetimes with the non-local Hanle effect to be commensurate with previous studies. The measured spin polarization efficiencies for hydrogenated graphene are higher than most oxide tunnel barriers on graphene, but not as high as with fluorinated graphene tunnel barriers. However, here we show that spin transport persists up to room temperature. Our results for the hydrogenated graphene tunnel barriers are compared with fluorinated tunnel barriers and we discuss the possibility that magnetic moments in the graphene tunnel barriers affect the spin transport of our devices.