Magnetism of single atoms on graphene

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Single atoms adsorbed on a surface represent a paradigm for investigating the ultimate size limit of a magnet. The main request for their use in information storage and computation is the magnetic bistability, which requires protecting the magnetization of an atom against thermal fluctuations and quantum tunneling. Different strategies have been attempted in this direction, aiming to increase the magnetic anisotropy energy of the adsorbed atom, decouple its spin from the conduction electron of the substrate, and tailor the angular symmetry of the crystal field of the surface [1]. Graphene, with its six-fold symmetric adsorption site is expected to provide close to purely uniaxial crystal field. In addition, its extremely high stiffness allows the suppression of spin-phonon coupling. These two elements are the key to obtain single atom magnets with long magnetic lifetimes, as recently demonstrated for Ho atoms on MgO/Ag(100) [2].

Here, I will present the recent advancements in the field of magnetic atoms on graphene. First, I will show how graphene can be successfully used to induce a large magnetic anisotropy in adsorbed Co atoms [3]. In addition, the direction of the easy magnetization axis of Co atoms can be controlled by growing graphene on different supporting metal substrates; while Co atoms on graphene/Pt(111) and graphene/Ir(111) show preferential magnetization orientation along the surface plane, Co on graphene/Ru(0001) exhibit a strong perpendicular magnetic anisotropy [4]. In all cases, the Co atoms exhibit paramagnetic behavior, indicating short magnetic lifetimes. Second, I will describe how graphene can be used to tailor the magnetic coupling between adsorbed Co atoms and a supporting ferromagnetic substrate. Co atoms on graphene/Ni(111) occupy two distinct adsorption sites, with different magnetic coupling to the underlying Ni(111) surface. Moreover, we observe a transition from antiferromagnetic to ferromagnetic coupling increasing the Co particle size from single atoms to few-atom clusters [5]. Finally, I will discuss the possibility of using graphene as a supporting substrate for rare earth atoms to obtain single atom magnets with long magnetic lifetimes.

References

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