2D Magnetic Heterostructures: from artificial magnets to smart molecular/2D heterostructures

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The controlled assembly of 2D materials in van der Waals heterostructures provides the opportunity to design unconventional materials with novel properties. Here I will illustrate this concept through two examples:

1) Artificial magnets obtained by creating a twisted 2D heterostructure formed by two ferromagnetic monolayers of CrSBr twisted by an angle of 90º [1]. Magneto-transport measurements in this new material show a multistep spin switching with the opening of hysteresis, which is absent in the pristine bilayer case (angle of 0º) [2], as a consequence of the competition between the inter-layer exchange interactions (which favor an antiparallel orientation of both spin layers) and the local spin anisotropy and an external magnetic field applied along the easy magnetic axis *b* (which tend to orient the spins along this easy axis).

2) Smart molecular/2D heterostructures obtained by interfacing stimuli-responsive magnetic molecules with graphene or semiconducting transition metal dichalcogenides (MoS_2 and WSe_2). The aim is that of tuning the properties of the "all surface" 2D material *via* an active control of the hybrid interface. This concept will provide an entire new class of smart molecular/2D heterostructures, which may be at the origin of a novel generation of hybrid materials and devices of direct application in highly topical fields like electronics, spintronics and straintronics. As smart-molecular systems I will choose magnetic spin-crossover materials able to switch between two spin states upon the application of an external stimulus (temperature, light or pressure) [3]. This spin transition is always accompanied by a significant change of volume in the material (by ca. 10%), so it can generate strain in its surrounding. I will show that in these heterostructures the electronic properties of graphene and the optical photoluminescence of monolayers of semiconducting metal dichalcogenides can be switched by light or by varying the temperature due to the strain concomitant to the spin transition [4-6].

References

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