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Spin crossover/graphene heterostructure based switchable optoelectronic devices

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Abstract:

Spin crossover (SCO) molecular materials exhibit a change of magnetic state that can be triggered by several external stimuli, in particular temperature, pressure, electric field and light irradiation. Despite their important potential, their use in multi-functional devices is hampered by several technological locks: (i) optoelectronic devices remain scarce because of complex intricate phenomena into the SCO channel, (ii) the low intrinsic conductivity of SCO material prevent their use for several sensing applications, (iii) optoelectronic switch based on SCO phenomena and operating at room temperature is very difficult to achieve. Today, I will present some of our recent achievements and on-going works illustrating the possibilities offered by ***SCO-2D materials heterostructures*** for optoelectronic applications, and how they can unlock these challenges.

First, magneto-opto-electronic properties are shown for a hybrid device constructed from a spin crossover (SCO) thin film of the $Fe[HB(3,5\text{-}(Me)_2Pz)_3]_2$ molecular material evaporated over a graphene sensing layer. The principle of electrical detection of the ***light-induced spin transition*** (LIESST) and reverse-LIESST effects in SCO/graphene heterostructures is demonstrated. **[1]** The switchable spin state of the molecular film is translated into a remanent change of the conductance of the graphene channel, using two distinct excitation wavelengths to write/erase the two states.

Then, I will present a hybrid device that can be switched at ***room temperature*** using light irradiation with non-volatile memory effect. The device is made of a graphene detector over which nanoparticles of the spin crossover $[Fe(Htrz)_2(trz)](PF_6)$ are deposited. For this molecular system, device operation at room temperature is realized, with multi-state stabilization obtained by varying the irradiation intensity or time. **[2]**

These results demonstrate how the electronic states of insulating molecular switches can be stored, read and manipulated by multiple-stimuli while transducing them into low impedance signal thanks to two-dimensional detectors. It reveals the full potential of mixed-dimensional heterostructures for molecular (opto)electronics and spintronics, and opens the door to the use of spin crossover materials for room temperature optoelectronic operations.

References:

[1] N. Konstantinov, *Journal of Materials Chemistry C* 2021, 9, 2712.
[2] J.F. Dayen et al., *submitted* 2021.