2D-0D HYBRID HETEROSTRUCTURES FOR SPINTRONICS AND NANOELECTRONICS

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With graphene as a flagship, and more recently with the discovery of semiconductors of few atoms thickness, the study of two dimensional ('2D') materials has become a major research field, allowing to re-explore condensed matter physics with one atom thick materials.[1] One of the main challenge of the field is now to develop novel heterostructures, referred as 2D-0d hybrids , combining 2D materials with another nanomaterial (colloid, molecule, etc..) in close contact with its surface (for a recent review see [2]). The leading motivation is to build up hybrid materials with new properties of interest for a wide range of electronics and spintronics applications, possibly also extending to the field of life sciences.

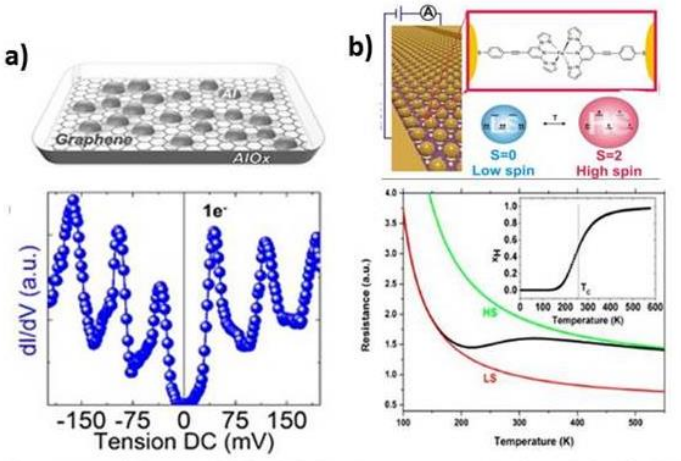

Figure : a) Scheme of Gr-0d heterostructure (top) and its single electron transport properties (bottom).[4] b) Scheme of hybrid nanoparticle-spin crossover molecule network (top) and resistance signature of molecular switching. [7]

Our team "Nano-device" recently demonstrated for the first time that graphene ('Gr') is a promising platform to develop graphene/0d-nanoclusters heterostructure, with unique single-electron transport properties.[3] We have also developed field effect transistor from 2D-MoSe2, a 2D material with superior spin splitting, and demonstrated how 2D material band-structure allows for fine control of charge injection processes at the 2d/metal interfaces.[4] Finally we have strong expertise in hybrid materials based on organic molecules and inorganic nanostructures. [5], [6]

This project aims at exploring the fabrication and transport properties of 2D-0d hybrids built from 2D materials and 0d spin crossover molecules ("SCO") and 0d inorganic nanoparticles. Main directions are :

- understanding the charge and spin transport mechanisms in 2D semiconductor/0d inorganic clusters, including mechanisms such as magneto-Coulomb and tunneling anisotropic magnetoresistance.
- exploring electrostatic and spin-orbit coupling in hybrid 2D material/SCO molecules. Here we target to study spin transport control in 2D material through chemical tuning of its electronics environment.

This PhD subject will be developed in collaboration with national partners (C2N;SPEC ;ICMCB) and international partners (KIT).

References :[1] K. S. Novoselov, et al. Science, 353, 9439 (2016); [2] D. Jariwala, et al. Nat. Mater., 16, 170 (2017); [3] F. Godel et al., Adv. Mater., 29, 1604837 (2017); [4] L.D.N. Mouafo et al., 2D Mater., 4, 015037 (2017) ; [5] J.-F. Dayen et al., Adv. Mater., 25, 400 (2013); [6] E. J. Devid et al., ACS Nano, 9, 4496 (2015).