Bound states induced by charged V dopants in monolayer WSe$_2$

Jean-Yves Veuillen
Florian Chiapello, Hanako Okuno†, Hervé Boukari, Matthieu Jamet†, Pierre Mallet
Institut Néel, CNRS and Université Grenoble Alpes, 38000 Grenoble, France
† IRIG, CEA and Université Grenoble Alpes, 38000 Grenoble, France
jean-yves.veuillen@neel.cnrs.fr

Besides exfoliation of bulk van Waals crystals [1], substitutional doping of two-dimensional (2D) semiconductors of the family 1H-MX$_2$ (M=Mo or W, X=S or Se) by 3d metal atoms is an appealing approach to prepare 2D magnetic layers [2] at the wafer scale using thin films growth techniques. V is in principle a favourable case for doping owing to i) the prediction of a magnetic state [3] and ii) the demonstration of its incorporation at M sites [4]. We present here the analysis by STM/STS of the electronic structure of V doped WSe$_2$ samples grown by MBE on graphitized SiC surfaces. Individual V dopants show up as large circular structures with a strong electronic contrast (Fig. 1 a-b), which together with the observation of a local upwards band bending [5] demonstrates that the dopants are negatively charged. The associated electronic potential induces one bound state (in-gap state) at the dopant site (Fig. 1 c). In line with this “electrostatic” picture, more strongly bound states appear for closely spaced V atoms. Charging is due to the band offset at the graphene/WSe$_2$ interface [6] and to the acceptor character of V atoms. Eventually, the excess charge would suppress the magnetic moment on the V atoms [4].

References


Figures

Figure 1: Electronic structure of isolated V dopants in monolayer WSe$_2$. a) and b) Constant current images of one dopant at negative (a) and positive (b) sample bias. c) Spectra taken at the site of a V dopant (red curve) and on a nearby bare WSe$_2$ spot (blue curve). The shaded area highlights the energy range of the valence band (VB) states of bare WSe$_2$. The green arrow points to the bound state systematically found at the V site, with 140 meV binding energy.