Colloquium Announcement

of the Collaborative Research Centre 951
"Hybrid Inorganic/Organic Systems for Opto-Electronics"

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Emergent Devices Enabled by van der Waals Contacts on 2D Transition Metal Dichalcogenides

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2D materials on mica and molecular liquid layers: strain vs. charge doping

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Emergent Devices Enabled by van der Waals Contacts on 2D Transition Metal Dichalcogenides

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Ultra-clean van der Waals (vdW) contacts on two dimensional (2D) transition metal dichalcogenides (TMDs) are essential for enabling several different types of high performance electronic devices. However, it has been challenging to make p-type contacts on 2D TMDs. I will present our recent work on making clean p-type contacts on 2D TMD using high work function metals such as Pt and Pd. The realization of p-type devices allows their integration with vdW contacted n-type devices. I will briefly describe our attempts to realize vertically integrated p-n junction devices. In addition, we have realised ferromagnetic (FM) vdW contacts. We have attempted to use the vdW gap between 2D materials and FM contact as a tunnel barrier for spin injection. Finally,I will discuss the results of vdW contacts on ferroelectric 2D materials to realize tunnel junction devices.

2D materials on mica and molecular liquid layers: strain vs. charge doping

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Mechanical exfoliation of 2D materials on atomically flat substrates such as mica is a simple and fast preparation method and therefore widely used. However, the process can induce substantial strain into the 2D material and the ambient conditions may cause water layers between mica and the 2D material. The latter can modify not only the strain distribution but also electronic charging of the 2D material due to the substrate. We demonstrate these effects using graphene as an example, where the two effects can be detected by Raman scattering independently. It allows to study in detail the influence of liquid layers, especially water, between mica and graphene. It is found that a water layer completely releases the strain of graphene and shields all charge doping from mica. Further investigations of the dynamical behavior of strain relaxation on liquid layers are presented that reveal a very high effective viscosity of the water/graphene system, which is highly reduced when deuterated water is used. The influence of the water layer on charge doping is also observed in MoS_2 and WS_2 exfoliated on mica und humid conditions. Use of dry conditions or exchange of the water layer against layer of organic solvents allows to switch reversibly the doping concentration which results in reversible shift of the photoluminescence (PL) spectra. Differences in the behavior of MoS_2 and WS_2 will be discussed based on PL and reflectance spectra. These investigations of strain and charge doping due to liquid layers are fundamental and necessary for the understanding of further experiments with dyes between 2D materials and atomically flat substrates.