Inorganic-organic Heterostructures formed by Non-Covalent Functionalization of MoS_2

Rita Siris, Tanja Stimpel-Lindner, Siwei Luo[***], Connor Cullen[**], Corinna Weiß[*], Frank Hauke[*], Georg S. Duesberg

Institute of Physics, EIT 2, Faculty of Electrical Engineering and Information Technology, Universität der Bundeswehr München, Germany

[*]Institute of Advanced Materials and Processes, ZMP, Group of Functional Carbon Allotropes, University Erlangen-Nuernberg, Germany

[**]Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College Dublin, Ireland

[***]Hunan Key Laboratory for Micro-Nano Energy Materials and Devices, Laboratory for Quantum Engineering and Micro-Nano Energy Technology, and School of Physics and Optoelectronics, Xiangtan University, Hunan, People's Republic of China

rita.siris@unibw.de

Abstract

Transition metal dichalcogenides (TMDs) represent a class of layered 2D materials with exciting electronic, optical and mechanical properties, making them suitable candidates for diverse applications in the fields of electronics and optoelectronics.

Due to their layered, high surface nature the properties of 2D materials strongly depend on the environment, offering highly variable platforms for on-surface chemical modification and functionalization. Therefore, merging the fields of non-covalent organic functionalization and 2D TMDs can lead to doping via charge transfer, resulting in tunable electrical properties in the heterostructures, which can be exploited in electrical devices such as diodes, FETs, chemiresistors or ChemFETs.

The approach discussed in this contribution includes non-covalent functionalization of organic molecules onto monolayer CVD grown MoS_2, forming self-assembled monolayers (SAMs) through van der Waals interactions. In particular, we focus on the on-chip non-covalent functionalization with perylene bisimide molecules, forming surface functionalized MoS_2 or molecule-encapsulated structures. The effect of molecular functionalization is investigated with Raman spectroscopy, XPS, TOF-SIMS surface analysis and scanning probe techniques. The potential of hybrid inorganic-organic structures is pointed out within this study, giving rise to possible electronic and optoelectronic applications.

References

[1] N. C. Berner, S. Winters, C. Backes, C. Yim, K. C. Dümbgen, I. Kaminska, S. Mackowski, A. A. Cafolla, A. Hirsch, G. S. Duesberg, Nanoscale, 7 (2015), 16337.

[2] S. Winters, S. Winters, N. C. Berner, R. Mishra, K. C. Dümbgen, C. Backes, M. Hegner, A. Hirsch, G. S. Duesberg, Chem. Commun., 51 (2015),16778.

[3] H. Kim, W. Kim, M. O'Brien, N. McEvoy, C. Yim, M. Marcia, F. Hauke, A. Hirsch, G. Kim, G. S. Duesberg, Nanoscale,10 (2018), 17557.