

Highly Selective, Non-Covalent Functionalization of MoS₂ – Inorganic-Organic Heterostructures

Rita Siris*

Corinna Weiß^{***}, Connor P. Cullen^{**}, Laura Höltgen^{*}, Tanja Stimpel-Lindner^{*}, Andreas Hirsch^{***}, Georg S. Duesberg^{*,**}

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

** Chair of Organic Chemistry II, Friedrich-Alexander Universität (FAU) Erlangen-Nürnberg, Germany

*** Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN) and Advanced Materials and Bioengineering Research (AMBER), School of Chemistry, Trinity College Dublin, Ireland

rita.siris@unibw.de

Abstract

Transition metal dichalcogenides (TMDs) represent a class of layered, two-dimensional (2D) van der Waals materials, exhibiting a broad variety of electronic, optical and mechanical properties.

Controlling and modifying these by non-covalent functionalization with organic molecules became a major tool to tailor the materials surface chemistry and reactivity.

Merging the fields of organics and 2D TMDs can potentially induce charge transfer doping, resulting in tunable electrical properties in the heterostructures, which can be exploited in electrical devices such as diodes, FETs, chemiresistors or ChemFETs.

In this contribution the formation of self-assembled monolayers on monolayer, chemical vapour deposited (CVD) MoS₂ from physisorbed polycyclic perylene Bisimide (PBI) dendrimers, forming surface functionalized MoS₂ or molecule-encapsulated structures, is described. The high selectivity of this functionalization route is further demonstrated with time-of-flight secondary ion mass spectrometry (TOF-SIMS) and combined infrared atomic force microscopy (AFM-IR) with resolutions beyond the optical resolution limit. The potential of

hybrid inorganic-organic structures is shown 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.

Figures

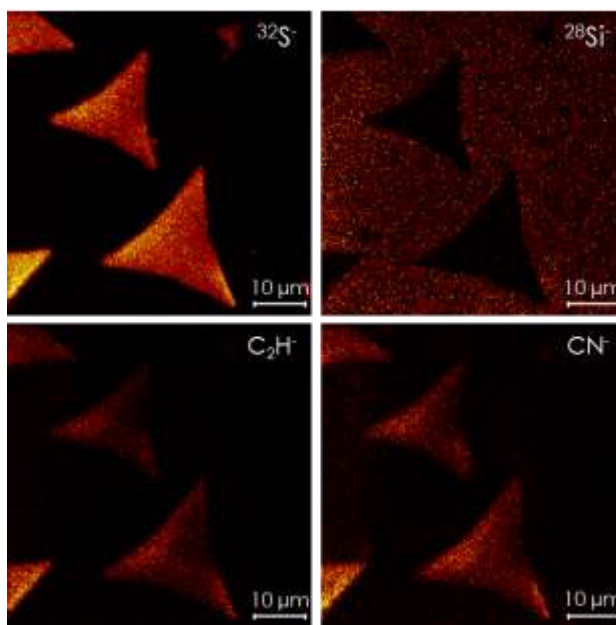


Figure 1: High-resolution TOF-SIMS maps of ³²S⁻, ²⁸Si⁻, CH₂⁻, and CN⁻ ions showing the planar distribution of the main elemental species on the surface of PBI functionalized MoS₂ on SiO₂. The CH₂⁻ and CN⁻ signals correspond to the PBI molecule, selectively deposited on the MoS₂ flake, represented by ³²S⁻ in contrast to the surrounding substrate, represented by ²⁸Si⁻ ions.