Formation of edge-bonded MoS_2-molecular nanowires interconnects by Ullmann coupling on MoS_2/Au(111)

Jonathan Rodríguez-Fernández[1], Søren Birthin Schmidt[1], Signe S. Grønborg[1] and Jeppe V. Lauritsen[1]

[1] *Interdisciplinary Nanoscience Center (iNANO), Aarhus University, 8000 Aarhus C, Denmark*
jonathan.rodriguez@inano.au.dk

Two-dimensional (2D) layered materials like, graphene, transition-metal dichalcogenide (TMDC) family and hexagonal boron nitride (hBN) [1, 2] have attracted a great interest in the recent decade due to remarkable electronic and optical properties, giving many applications in different areas such as catalyst, solar-cells, gas sensors, photodetectors and field-effect transistors. In particular, MoS_2 show promising electronic and optoelectronic properties for future nanoelectronic applications. Combining 2D materials with organic molecules opens up for new opportunities to build hybrid nanostructures, where the properties of the 2D materials can be tuned through the incorporation of the organic molecules[3]. Atomically hybrid nanostructures may be created by surface-confined coupling reactions, where the organic molecules can be self-assembled on the substrate via the Ullman coupling reaction by dehalogenation and covalent C-C bond formations [4] and connect to MoS_2 active sites via this radical molecule after debromination.

In this work we explore the chemistry required to selectivity edge-bind self-assembled molecular interconnects to Au-supported MoS_2 islands by using variable temperature scanning tunneling microscopy (VT-STM). Based on the Ullman coupling of 2,8-Dibromodibenzothiophene (2,8-DBDBT) we achieve a site specific molecular connection between corner sites of two different single layer MoS_2 islands. Due to the synthesis procedure of MoS_2/Au(111) a post-synthesis hydrogen treatment of the sample is crucial for enabling chain formation on the Au terraces as residual sulfur, which functions as an inhibitor of chain formation, is otherwise present on the Au surface. During growth of the molecular nanowires, we observe how the molecular wires extend towards neighboring islands where it, with almost 100% selectivity, connects to corner sites of the islands. Previous studies have reported similar hydrogen anneal lead to a reduction of sulfur coverage of the edges of MoS_2 based nanoparticles and it is hence speculated if a similar edge reduction is responsible for the attachment of the nanowire.

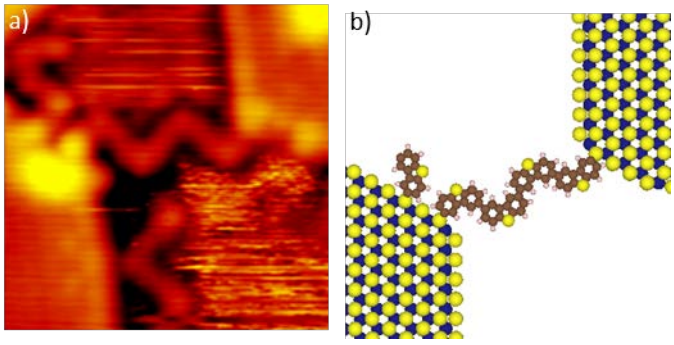

Figure 1: a) STM image of two MoS_2 nanoislands interconnect by 2,8-DBDBT on Au(111). b) Tentative ball model.

References:
[1] X. Li, H. Zhu, Two-dimensional MoS2: Properties, preparation, and applications, Journal of Materiomics, 1 (2015) 33-44.
[2] K.S. Novoselov, A. Mishchenko, A. Carvalho, A.H. Castro Neto, 2D materials and van der Waals heterostructures, Science, 353 (2016).
[3] Y. Huang, W. Zheng, Y. Qiu, P. Hu, Effects of Organic Molecules with Different Structures and Absorption Bandwidth on Modulating Photoresponse of MoS2 Photodetector, ACS Applied Materials & Interfaces, 8 (2016) 23362-23370.
[4] M. Lackinger, Surface-assisted Ullmann coupling, Chemical Communications, 53 (2017) 7872-7885.