Contribution ID: **343** Type: **Plenary**

The fascinating world of organic nanocrystals on 2D materials

Tuesday 19 June 2018 08:30 (45 minutes)

Crystalline films of small conjugated molecules offer attractive potential for fabricating organic solar cells, organic light emitting diodes (LEDs), and organic field effect transistors (OFETs) on flexible substrates. Here, the novel two-dimensional (2D) van der Waals materials like conducting graphene (Gr), insulating ultrathin hexagonal boron nitride (hBN) or semiconducting transition metal dichalcogenides come into play. Gr for instance offers potential application as transparent conductive electrode in organic solar cells and LEDs replacing indium tin oxide, whereas hBN can be used as ultrathin flexible dielectric in OFETs. Since small conjugated molecules like the rod-like molecule para-hexaphenyl (6P) fit well to the hexagonal structure of 2D materials, growth of 6P can be expected in a lying configuration. This has indeed been observed by low-energy electron microscopy for growth of 6P on Pt(111) supported Gr in a layer by-layer fashion [1].

Here, we report on the self-assembly of crystalline needles composed of rod-like molecules on exfoliated, wrinkle-free Gr [2] and hBN [3], both transferred onto SiO2. The needles are several 10 nm wide and a few nm high, they can extend to several 10 µm in length. The discrete needle directions with respect to armchair and zigzag directions of the substrates were determined by atomic-force microscopy (AFM) in conjunction with density functional theory calculations.
Through in-situ measurements during molecule deposition on Gr in field-effect transistor device geometries, the charge transfer at the interface was directly probed. The amount of charge transferred per adsorbed molecule is only about one thousandth of an electron transferred per molecule [4]. Further, electrostatic force microscopy (EFM) based charging and charge spreading experiments demonstrate the optoelectronic properties of the organic nanoneedles. Finally, AFM based manipulation is employed to probe the mechanical robustness of the 2D materials [5] as well as of the organic nanocrystals.

Work has been performed in collaboration with G. Hlawacek, M. Kratzer, A. Matković, J. Genser, G. Lin, A. Cizek, A. Vukusić (Leoben), R. van Gastel, F.S. Khokhar, B. Poelsema (University of Twente, NL), J. Vujin, B. Vasić, Stanković, R. Gajić (University of Belgrade, Serbia), Z. Chen, O. Siri, T. Léoni, C. Becker (Aix Marseille Université, France), D. Lüftner, and P. Puschnig (University of Graz, Austria).

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Session Classification: Plenary session

Track Classification: Nanometer Structures & Nanotechnology