HL 26: Poster 2D Materials Beyond Graphene: Growth, Structure and Substrate Interaction (joint session O/HL)

Time: Tuesday 13:30–15:30 Location: P3

HL 26.1 Tue 13:30 P3

Two-dimensional hexagonal β-GeSe on Au(111) — •Dina Wilks, Veronika Blecker, Muhammad Ali Martuza, Marina Hammer, Christoph Schuster, Paulus Aleksa, and Carsten Busse — Walter-Flex-Straße 3, 57072 Siegen, Germany

Two-dimensional (2D) group-IV monochalcogenides (general form MX with M=Sn, Ge; X=S, Se, Te) demonstrate a high degree of polymorphism. While the orthorhombic phase, widely studied for its in-plane ferroelectricity, holds significant promise, experimental studies on other polymorphs remain scarce.
Here, we investigate the growth and structure of 2D hexagonal β-GeSe on Au(111). This phase is predicted to exhibit out-of-plane ferroelectricity, which could be more technologically feasible for device integration. Samples are prepared using molecular beam epitaxy (MBE) with GeSe powder as the source material and analyzed with low energy electron diffraction (LEED) and scanning tunneling microscopy (STM). The degree of structural order was found to depend sensitively on the heat treatment. We observe a (5×5) superstructure relative to Au(111), accompanied by a continuously varying density of states (DOS) across the superstructure's unit cell. Additionally, an intriguing self-similar pattern emerges, which can be attributed to antiphase grain boundaries. These boundaries exhibit metallic behaviour near the Fermi level, highlighting their potential significance in the electronic properties of the system.

HL 26.2 Tue 13:30 P3

Scanning Tunneling Microscopy and Spectroscopy of epitaxial grown TaS_2 on GaN (0001) — •Jan-Niclas Schmidt, Constantin Hilbrunner, Georg A. Traeger, Jörg Malindretos, Angela Rizzi, and Martin Wenderoth — University of Göttingen, IV. Physikalisches Institut, Fridrich-Hund-Platz 1, 37077 Göttingen

Tantalum Disulfide crystals are interesting due to its complex phase diagram including the effect of Charge Density Waves. We are interested in how the layer thickness influences properties of Tantalum Disulfide. With Molecular Beam Epitaxy a three monolayer thick film of 2H-Tantalum Disulfide was grown on Gallium Nitride. To gain insight into the growth mechanism, the sample was transferred to a low temperature Scanning Tunneling Microscope (STM) operated at 80 K. To avoid any surface contamination, the transfer was done with a portable ultrahigh vacuum chamber. The constant-current STM-topography show small nanometer-sized, trigonal islands on a rough layer with some holes. The spectroscopy data show metallic behavior for the island as well as for the layer below.
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HL 26.3 Tue 13:30 P3

Growth dynamics of 2D materials on Ir(111) — •Smruti Ranjan Mohanty, Marko Kriegel, Frank Meyer zu Heringdorf, and Michael Horn- von Hoegen — Faculty of Physics and Center for Nanointegration, Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47048 Duisburg, Germany

The structure and morphology of 2D materials are profoundly influenced by the choice of growth substrates, with noble metal substrates offering enhanced catalytic activity and complex surface morphology facilitating precise control over the growth of 2D materials. Employing low-energy electron microscopy (LEEM), we investigated the kinetics of graphene island nucleation during the CVD of ethylene on Ir(111) at growth temperatures ranging from 750°C to 1050°C for various dosing pressures. Graphene islands nucleate heterogeneously at Ir(111) step edges, leading to edge decorations, but a transition to homogeneous nucleation occurs at island densities lower than the step density. The strong variation in island density as a function of growth temperature and dosing pressure is explained by Venables nucleation theory, with the near-linear dependence on dosing pressure attributed to a critical nucleus size (i*) of 5. The work presented here also extends to the growth and characterization of other atomically thin 2D materials, including hexagonal boron nitride (hBN), and borophene on Ir(111). The investigation reveals complex growth mechanisms, the emergence of Moiré superlattices, and substrate-influenced interactions, providing insights for designing heterostructures and functional materials with significant potential for next-generation technological applications.

HL 26.4 Tue 13:30 P3

Incommensurability and negative thermal expansion of single-layer hexagonal boron nitride — •Marko Kriegel[1], Karim Omambac[1], Steffen Franzka[2], Frank Meyer zu Heringdorf[1,2], and Michael Horn-von Hoegen[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany — [2]Interdisciplinary Center for Analytics on the Nanoscale (ICAN), Carl-Benz-Str. 199, 47057 Duisburg, Germany

The emerging field of straintronics, i.e., the control and utilization of the strain state of 2D-materials, is of great importance for their technological development, specifically in view of their future incorporation into van der Waals heterostructures. To gain fundamental insight into structural peculiarities of two-dimensional systems, single-layer hexagonal boron nitride (hBN) grown on Ir(1 1 1) by chemical vapor deposition was used as a prototypical model system: High-resolution reciprocal space mapping reveals the incommensurate nature of the material system by measuring the hBN in plane lattice parameter with high precision, facilitated by the moiré magnification effect in electron diffraction. In a growth temperature (T_g) regime of 700 to 1150°C an average lattice parameter of 2.496 ± 0.006 Å was found. Eventually, careful disentanglement of the hBN and substrate behavior for rising T_g allowed the determination of a negative thermal expansion coefficient of $\alpha_{hBN} = 2.4 \pm 1.2 \times 10^{-6}\,K^{-1}$ for free-standing hBN.[1] [1] M. Kriegel et al. Appl. Surf. Sci. 624 (2023) 157156

HL 26.5 Tue 13:30 P3

UHV-CVD on Ir(111) for the Growth of 2D Materials — •Niels Ganser[1], Marko Kriegel[1], Karim Omambac[1], Marin Petrovic[2], Christian Brand[1], Steffen Franzka[3], Birk Finke[1], Tobias Hartl[4], Thomas Michely[4], Frank-Joachim Meyer zu Heringdorf[1], and Michael Horn-von Hoegen[1] — [1]Universität Duisburg-Essen — [2]Institute of Physics, Zagreb — [3]ICAN, Duisburg — [4]Universität zu Köln

Hexagonal boron nitride (hBN) can be grown by scalable chemical vapor deposition (CVD) from a borazine $B_3N_3H_6$ precursor. Here we show that the hBN quality depends strongly on the growth temperature T_g and the dosing pressure p.

Combined SPA-LEED and LEEM measurements show a strong dependence of n on p. We find that the quality of the hBN layers that can be achieved by increasing T_g is limited by the process of disintegration of the borazine at $T_g > 950\,°C$ resulting in growth of borophene (2D Boron) instead [1]. Thus, it is possible to selectively grow either hBN or borophene from the same precursor [2].

Corroborating SPA-LEED measurements reveal a negative thermal expansion coefficient of $\alpha = (-2.4 \pm 1.2) \times 10^{-6}\,K^{-1}$ for 2D hBN in the temperature regime between 700 and 1100 °C. This finding can be explained by Lifshitz' membrane effect [3].

[1] Lifshitz, I., Zh. Eksp. Teor. Fiz. 22, 475 (1952)
[2] Omambac, K. et al., ACS Nano 15, 7421 (2021)
[3] Omambac, K. et al., ACS Nano 17, 17946 (2023)