Understanding Materials from Synthesis to Electronic Structure at the MAESTRO Beamline

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MAESTRO, the Microscopic And Electronic Structure Observatory, is a new user facility at the Advanced Light Source synchrotron, dedicated to *in situ* thin film synthesis and characterization using multiple growth and characterization tools. Films are synthesized singularly by, or in combinations of, Pulsed Laser Deposition (PLD), Molecular Beam Epitaxy (MBE), or mechanical micro exfoliation under ultra high vacuum or purified Ar environments. Samples are characterized by offline tools such as ESCA and LEEM/nanoLEED. But the main focus is on spatially-dependent characterization of materials' electronic structure by Angle Resolved Photoelectron Spectroscopy (ARPES). The chambers are connected by an automated high speed sample transfer system to ensure surface preservation as samples are moved efficiently from station to station, with the goal of complete characterization of materials growth phase diagrams, and the interplay of film morphology, electronic structure, and many-body interactions.

MAESTRO incorporates three ARPES systems with complementary capabilities in temporal, spatial, and energy resolution from the VUV to the soft X-ray at resolving power of 30000, sufficient to resolve not only band structure but also the effects of many-body interactions. The **NanoARPES** chamber offers routine spatial resolutions between 120 to 500 nm using a Fresnel zone plates or an elliptical capillary optic, respectively. The **MicroARPES** chamber features a traditional variable temperature stage (20 to 2300K) with probe size down to 12 micron. The **PEEM/LEEM** chamber features real time, full field bright and dark-field imaging based on ARPES, core levels, and LEED, as well as a 200nm nanoLEED probe, for realtime monitoring of growth morphology and adsorbate chemistry.

In this talk, I will present early results to highlight these capabilities, including the characterization of defects, electrostatic variations, and quasiparticle dynamics in CVD-grown[1] and exfoliated[2] 2D chalcogenide materials interacting with graphene and other substrates. I will also briefly discuss ongoing developments to apply machine learning to guide both the synthesis and measurement degrees of freedom. Such efforts aim at accelerating both the optimization and phase identification of new materials and if successful will demonstrate synchrotron beamlines' potential utility for materials discovery in addition to their more established role in characterization.

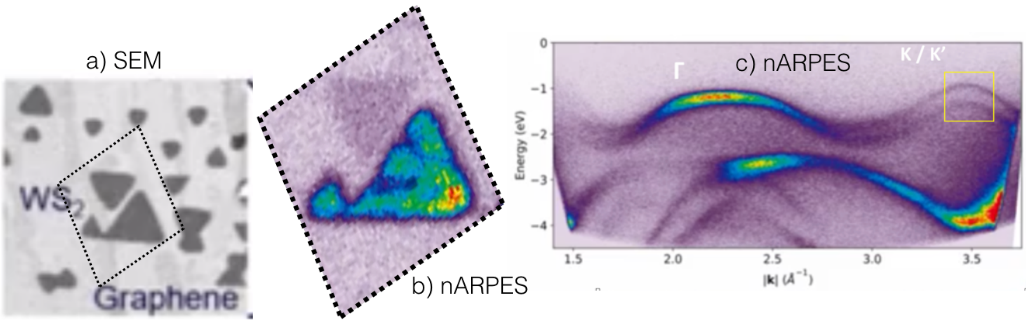

Figure. a) SEM image of ML graphene islands grown by chemical vapor deposition on epitaxial graphene. (b) nanoARPES image of the very same islands, using valence band intensity at the K/K' points, shown in (c) for a representative location on the large island. The image contrast between large and medium islands is due to the different ARPES cross sections for K vs K' bands (the islands' crystal structure are rotated by 60° to each other [1]

References:
[1] C. Kastl, C. Chen, R. Koch et al, 2D Materials, accepted.
[2] J. Katoch, S. Ulstrup, R. J. Koch et al. , Nat. Phys. 14, 355–359 (2018).