Advanced soft-x ray absorption and photoemission spectroscopy of 2D materials and their heterostructures

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The unique properties and versatility of 2D materials have garnered significant interest for numerous applications, including electronics, optoelectronics, and catalysis. To harness the full potential of these materials in technological devices, it is crucial to accurately identify and quantify factors such as doping, intercalation, and substrate interactions, as well as ensure stability in humid and oxidative environments. Advanced techniques are essential for these analyses.

Among the available methods, synchrotron-based high-resolution X-ray photoelectron spectroscopy (PES) with tunable photon energies, combined with X-ray absorption spectroscopy (XAS), stands out. This approach allows for comprehensive electronic characterization, providing unique information with elemental sensitivity at the atomic orbital level. These insights are invaluable for advancing the application of 2D materials in various high-tech fields.

The BACH beamline offers a multi-spectroscopy technique approach by combining PES and XAS in the EUV-soft X-ray photon energy range. The beamline provides selectable light polarization, high resolving power in different environments, and various time scales. This setup enables the investigation of the electronic, chemical, structural, magnetic, and dynamical properties of solid surfaces, interfaces, thin films. The range of techniques and spectroscopy methods available at this beamline in a single endstation is unique. Additionally, samples such as 2D layers, thin metallic and oxide films, molecular layers, and metallorganic architectures can be prepared and grown in situ.

In recent years, in-depth characterization of layered transition metal dichalcogenides synthesized in monolayer or few-layer forms, graphene, hexagonal boron nitride, and their heterostructures has been achieved. This presentation will provide an overview of representative scientific results on 2D materials obtained using advanced soft X-ray spectroscopy methods, focusing particularly on recent findings regarding the integration of 2D materials (graphene, MoS_2) with GaN wide bandgap semiconductors.