Surface and Interface Engineering in Two-Dimensional Materials: Insights from Advanced Experimental Investigations

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Two-dimensional van der Waals materials provide an exceptional platform for exploring how electronic properties emerge from the interplay between reduced dimensionality, crystal symmetry, orbital character and surface or interface effects. Their atomically thin nature makes them particularly sensitive to local structural distortions, external perturbations and contact-induced phenomena, while also requiring advanced experimental approaches capable of probing electronic properties with high surface sensitivity.

In this presentation are selected representative results obtained by using advanced surface-sensitive experimental approaches that enable the investigation of 2D materials. A particular emphasis will be placed on the role of research infrastructures and on the access to advanced experimental capabilities available through the CERIC-ERIC programme, which enables detailed investigations of surfaces, interfaces and low-dimensional materials.

The results demonstrate how preferencial adsorption postions, lattice registry, interfacial coupling and local structural distortions strongly influence the electronic landscape of 2D systems, leading to spatial modulations of charge density, work function and local density of states. Local nano-contacts further reveal how mechanical deformation and layer decoupling can be used to tune charge injection and junction behavior at the nanoscale.

By combining photoemission spectroscopy, polarization-dependent x-ray absorption, electron diffraction and first-principles calculations, our studies separate the roles of structural asymmetry and electronic orbital character in driving anisotropic electronic responses and how intrinsic properties can be controlled. Overall, these findings highlight the critical role of surfaces, interfaces and local structural effects in shaping the electronic behavior of 2D materials, offering new pathways for their controlled manipulation in future nanoscale and quantum technologies.

Short bio:

Borca Bogdana is a senior scientist at the National Institute of Materials Physics, Romania and an experimental condensed matter physicist with expertise in surface science and nanoscience. Her research focuses on the electronic and magnetic/spintronic properties of nanoscale and molecular systems, graphene and 2D materials. She received her PhD in 2007 through a co-tutoring program between Joseph Fourier University (Institut Néel), France and Babes-Bolyai University, Romania. She held postdoctoral positions and conducted research visits at leading European institutes and synchrotron facilities. She recently completed a Fulbright Visiting Scholar fellowship at Penn State University, USA.