Electrical characterization of 2D materials via advanced Scanning Probe Microscopy modes

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In an ever-advancing miniaturization of our modern, high-tech world, thin films and multilayer structures gain increasing attention as they could pave the way to novel applications like ultra-thin ferroelectrics, protective coatings with adjustable friction, or tailored conductive properties [1-3]. In this sense, the thinnest films imaginable are single layers of 2D materials like graphene, hexagonal boron nitride (hBN), or transition metal dichalcogenides (TMDs) like (tungsten disulfide) WS_2. However, reliable application of such nanometer-sized structures requires a correlative metrology that resolves such features [4].

Here, atomic force microscopy (AFM) has been established as a most versatile tool for the characterization of structures and interfaces with sub-nanometer resolution. The unique utilization of a nanometric probe in close proximity to the sample allows for a series of advanced characterizations of the material properties beyond crucial topographical information such as step height, roughness, and lattice periodicity. Nanomechanical measurements to map the adhesion, stiffness, or even friction with unparalleled high resolution can be performed. The ability to apply a bias locally permits to correlate these properties with additional features like the work function and conductance and thus provides a comprehensive investigation of morphology and defects with a broad spectrum of local information, which helps to optimize the preparation and development of new materials. Lastly, a high degree of automation enables AFM systems to program batch processes for wafer sampling, e.g. to study sample degradation vs. time caused by various factors, including illumination or humidity.

In this talk, we demonstrate the versatility of AFM via a nanoscale characterization and manipulation of switchable ferroelectric domains in hBN/graphene heterostructures. Moreover, we present a study on light-induced WS_2 coating degradation vs. time and outline local electrical measurements to investigate the properties of graphene wrinkles and MoS_2 multi-layers.

References:

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