NenoVision

Application Note

Characterization of 2D nanomaterials using AFM-in-SEM LiteScope™

2D nanomaterials are very promising for many applications, including flexible electronics, nanodevices, precise sensors, protective coating, solar cells, drug delivery, DNA sequencing, and many others. Even though they have many advantages, their production faces some challenges. For example, it is difficult to grow large and defect-free films of nanomaterials. The analysis of such structures can be challenging due to the size, thickness, and poor SEM contrast of the thin layers. LiteScope represents the best possible solution on how to deal with all these issues.

LiteScope brings a 3D to your SEM image.

LiteScope is a powerful tool for the characterization of nanostructures and their properties.

LiteScope is an atomic force microscope (AFM) specially designed for integration into SEM systems. It is equipped with unique Correlative Probe and Electron Microscopy (CPEM™) technology allowing simultaneous measurement of both SEM and AFM images and precise in-time image correlation resulting in a 3D CPEM view.

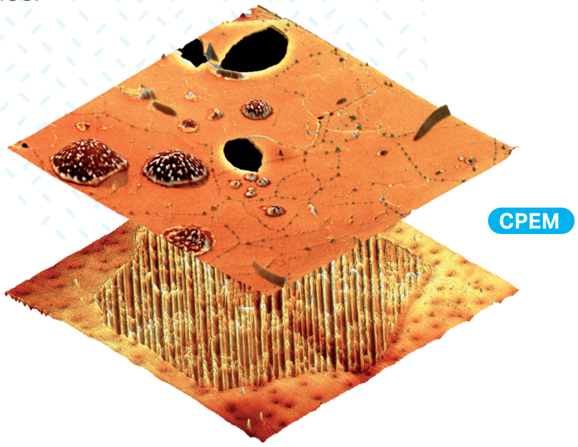

Figure 2. **Top:** 3D CPEM view of a thin layer of $BiFeO_3$ on a HOPG substrate. **Bottom:** A monolayer of graphene on a Cu foil preserving the rough surface of copper.

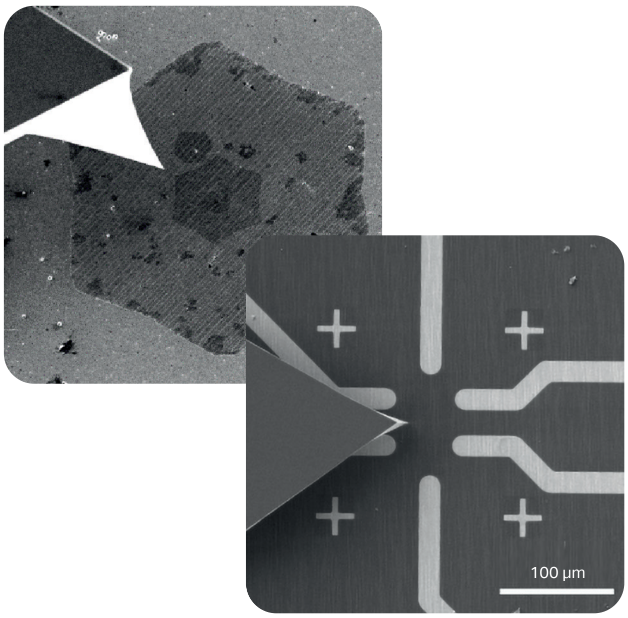

Figure 1: Precise AFM tip navigation to the region of interest.

LiteScope key advantages for 2D nanomaterials analysis

- Fast and precise localization of nanostructures and nanodevices (**Figure 1**)
- Monolayer resolution
- 3D surface topography extension of the SEM image (**Figure 2**)
- CPEM technology for correlative imaging
- Optimization of the nanomaterial production process
- Quality control and defect localization
- Vacuum preservation and minimal sample handling
- Wide range of measurement modes enable complex in-situ sample surface analysis:
  - Topography (AFM, STM)
  - Electrical properties (C-AFM, C-CPEM, PFM, KPFM, spectroscopy modes)
  - Mechanical properties (energy dissipation, FMM, force-distance curves, nanoindentation)

Monolayer resolution

AFM LiteScope offers a monolayer resolution of 2D materials. As depicted in **Figure 3**, the SEM's great contrast clearly identifies graphene layers, however, based solely on the SEM image it is difficult to distinguish, whether the graphene layers grow from individual cracks or terraces of the substrate. On the other hand, the AFM topography provides precise information on the height and depth of the surface features. The 3D CPEM view, combining the SEM contrast and AFM topography, enables you to clearly visualize individual layers of graphene and the direction of their growth.

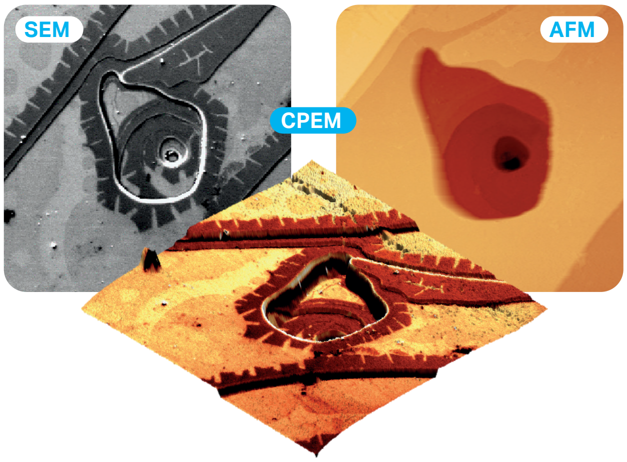

Figure 3: SEM image, AFM image, and correlated 3D CPEM view of graphene on SiC terraces.

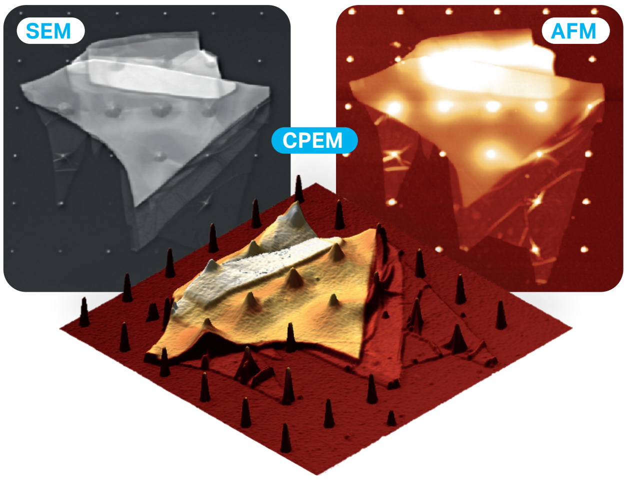

Figure 4: SEM image, AFM image, and 3D CPEM view of WSe_2 flake on Si nanopillars.

Profiling of nanostructures

3D topography extension is a major feature of LiteScope and CPEM technology. CPEM view, merging both the AFM and SEM data, is of particular advantage when analyzing complex samples, such as combination of 1D and 2D materials. In this case, exfoliated WSe_2 flakes on Si nanopillars were studied. A monolayer of WSe_2 is barely visible in the SEM image, but it can be nicely seen by AFM. Scalable 3D CPEM view of correlated data helps to visualize and understand how the flakes cover the nanopillars, see **Figure 4**. A certain shape of the WSe_2 monolayer over the nanopillars creates a single-photon emitter. This application aims to be used for quantum cryptography, which makes communication more secure.

2D materials quality analysis

AFM LiteScope enables fast and accurate optimization of the layer production process and further analysis of the layer quality and its properties. Graphene Hall bars have potential use in the automotive, aviation, or semiconductor industry. AFM-in-SEM approach allows in-situ correlative microscopy with CPEM technology, which facilitates investigation of the graphene Hall bar structure after the deposition process. The images in **Figure 5** demonstrate both the material contrast, revealing the graphene layer and surface topography. Thanks to the multiple available measurement modes mentioned earlier, the quality of the contact between graphene Hall bar and gold contact can be analyzed as well as the roughness and other material properties.

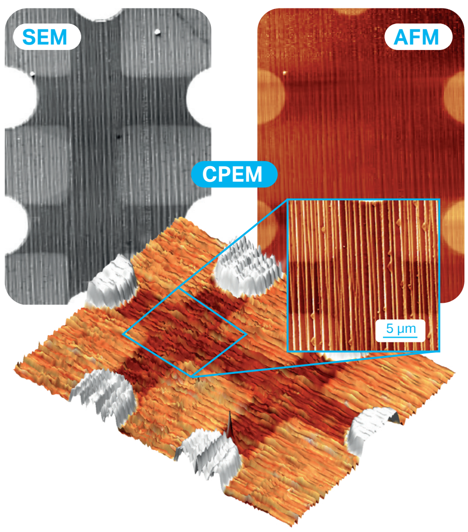

Figure 5: SEM image, AFM image, and 3D CPEM view of a graphene Hall bar on SiC substrate.

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