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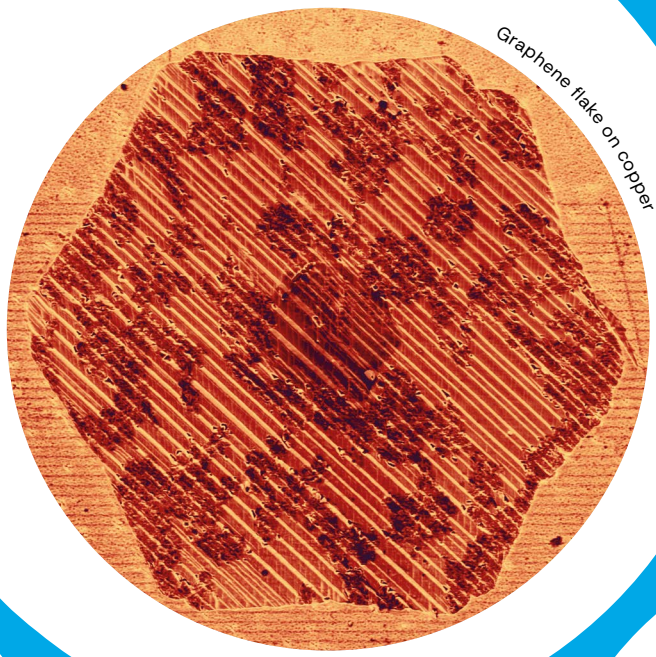

2D Materials Characterization using AFM-in-SEM LiteScope™

application note

Key added values

- Complex understanding and comparison of mechanical, electrical, piezoelectric, magnetic, chemical properties, etc.
- Precise flake location and surface analysis
- Multiple flake features detection within single acquisition

Application areas

- Fundamental research of low dimensional materials (e. g., graphene, BNNSs, TMDCs, MXenes)
  - new
  - functionalized
  - heterostructured
- Fabrication Processes
  - quality control and diagnostics
  - reproducible and reliable
  - defect characterization

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2D Materials Characterization using AFM-in-SEM LiteScope™

Complex characterization of **2D materials** and understanding their properties, such as **topography, mechanical, electrical,** and **magnetic** characteristics in relation to **chemical** composition, is fundamental for the development and practical application of functionalized 2D materials.

2D materials are vital across various industries such as **automotive, semiconductors, petrochemistry,** and **aircraft engines** due to their outstanding properties. Understanding their **microstructure, defects,** and **mechanical or electrical traits** is crucial. Effective fabrication and quality control are key to maximizing their potential in advanced technologies.

Molybdenum Disulfide

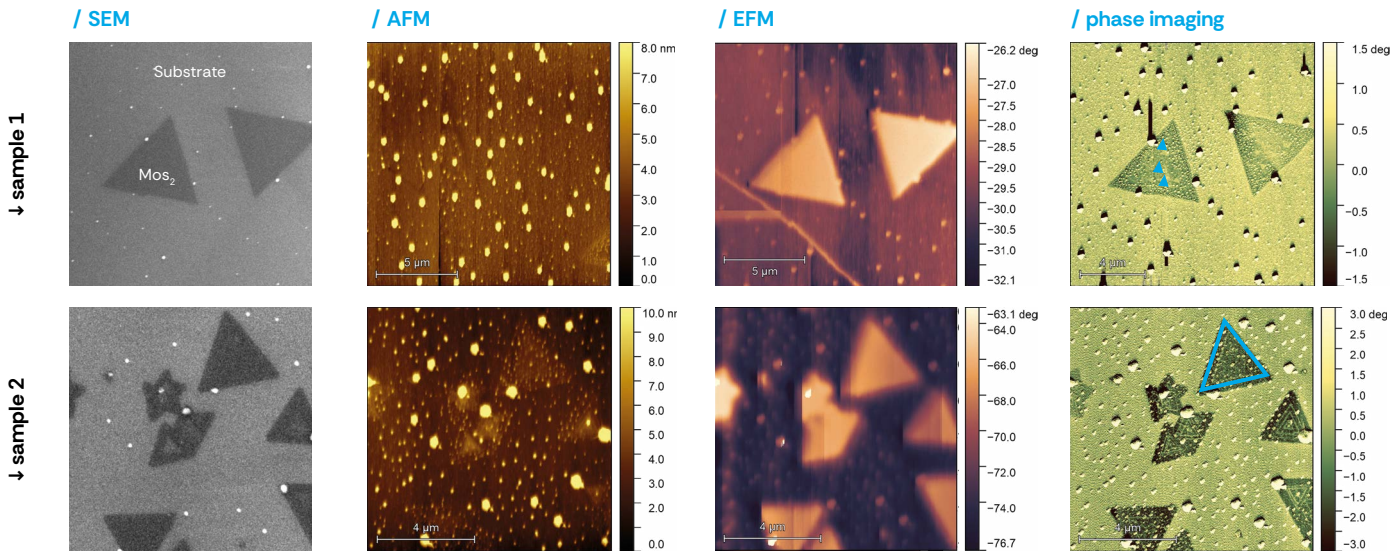
Sample courtesy of Zdenek Sofer, University of Chemistry and Technology Prague, CZ.

Molybdenum Disulfide (MoS_2) is one of the **2D layered TMDCs** suitable as earth-abundant catalysts or 2D semiconductors in **advanced electronic devices**. The fabrication conditions of such monolayers need to be well-understood to ensure **reliable** and **reproducible properties**, such as flexibility, unique electric, or mechanical properties.

We present **AFM-in-SEM solution** for **precise** and **complex analysis** of **MoS_2 flakes** grown by CVD on thick SiO_2/Si.

All techniques – SEM, AFM, EFM, and phase imaging – were **measured at once** on two sets of samples with diverse fabrication conditions. This approach enables the **comparison of results** to identify **optimal fabrication parameters** for achieving the **desired sample features**.

Complex MoS_2 characterization using AFM topography, SEM, EFM and phase imaging.



SEM easily locates flakes thanks to high material contrast but offers limited morphological information.

AFM topography obtains surface roughness and heights of flakes and impurities, which appear less significant in SEM images.

EFM observes surface charge distribution and electric response on applied bias.

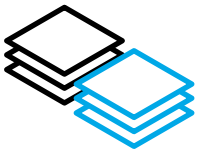
Phase imaging identifies harder flakes and softer substrate, also detecting edges of additional growing layers.

Key benefits and features

+ Precise monolayer detection.
+ Specially designed probes facilitate the execution of multiple modes in a single acquisition.
+ Efficient data handling and processing within the NenoView software.
+ Fast flake location and tip navigation via SEM.
+ Easy correlation with additional SEM techniques, e.g., chemical analyses.
+ Large 80x80 µm scan range.

Measurement workflow

Flake selection



Multiple measurements

Merging layers

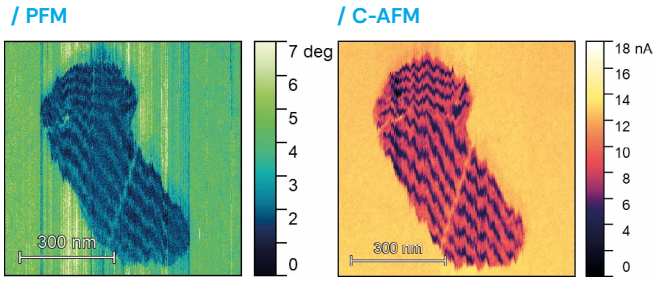
Data correlation and processing

Twisted Bilayer Graphene

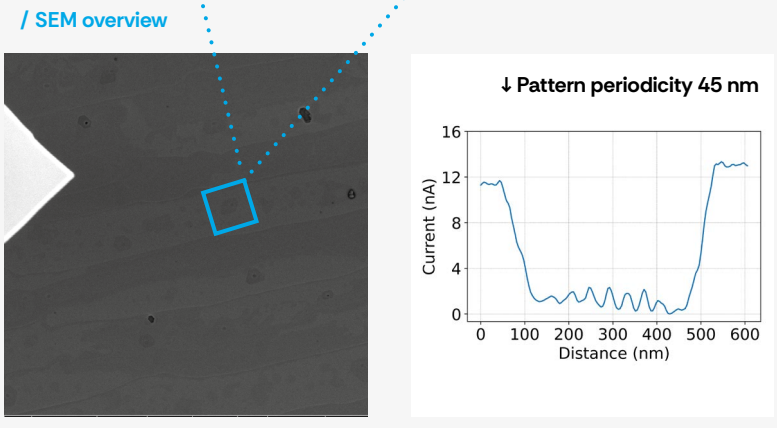
Sample courtesy of Jan Kunc, Czech Technical University in Prague, CZ.

Twisted bilayer graphene (TBLG) is studied for its ability to **create new tunable electronic behavior**. The twist affects the size and shape of the bandgap, resulting in a periodic modulation of atomic structure visible as moire patterns in electrical properties. These structures are promising for use in **sensors, photonic**, and **electronic devices**.

Moire pattern acquisition of TBLG using C-AFM and PFM analysis.



We measured the **electrical properties** of graphene double layers on SiC. The **diverse PFM** and **C-AFM** contrast across the sample indicate that both **twisted** and **untwisted graphene double layers** are present. We focused on **twisted** parts where we observe the modulation as **moire patterns** with periodicity of 45 nm.



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LiteScope™ solution for 2D materials characterization

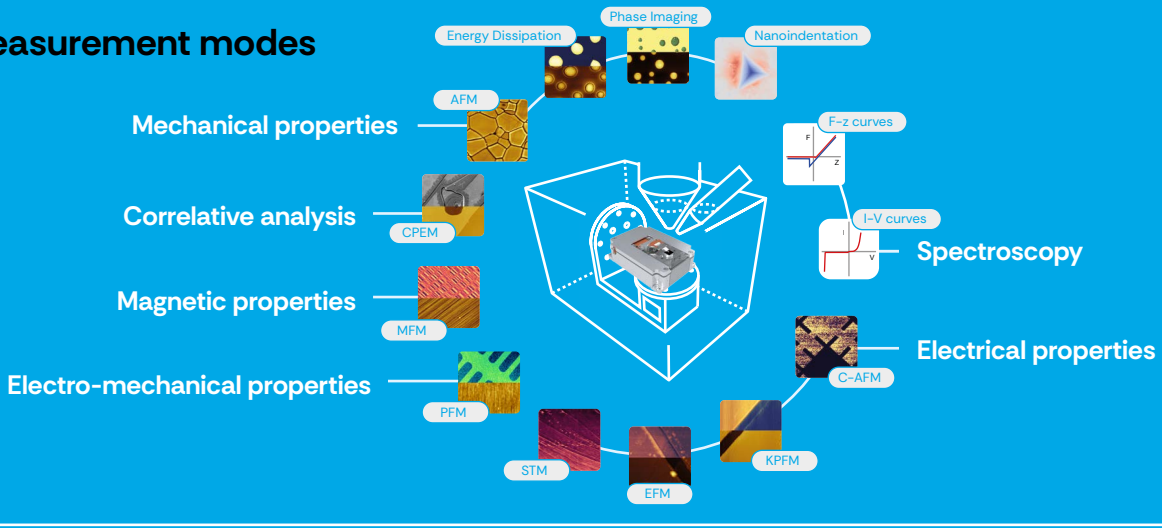
In-situ multimodal flake characterization

Experience LiteScope's multimodal capabilities with strong SEM material contrast and achieve consistent, reliable, and complex results under uniform controlled conditions.

Enhanced data analysis tools

Utilize NenoView's comprehensive in-software 2D flake analysis functions such as diverse plane fittings or intuitive layer merger of different output measurements into a single file.

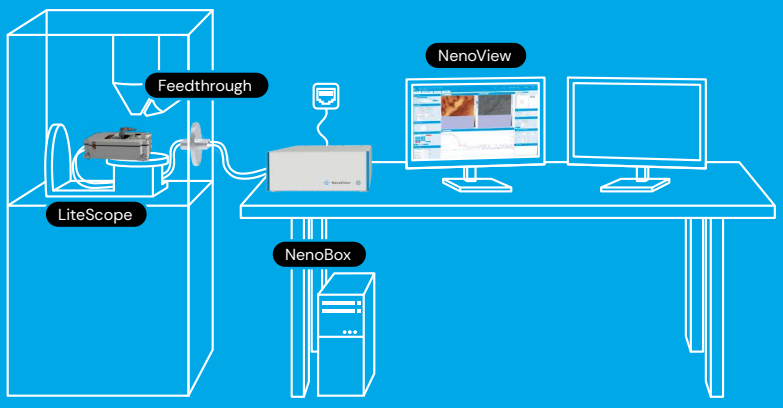
Measurement modes



LiteScope Setup →

NenoVision combines tradition and expertise with unique solutions in nanoscale AFM-in-SEM microscopy.

Thanks to its optimized design, the AFM LiteScope seamlessly integrates into most SEM systems produced by Thermo Fisher Scientific, TESCAN, ZEISS, Hitachi, Jeol, and their accessories.



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