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Better in Vacuum - how vacuum can improve investigation of 2D materials using conductive Atomic Force Microscopy (AFM)

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In the last years, the aim of semiconductor industry to produce nanoscale-sized devices determined an increasing interest for a series of 2D materials. Among them, transition metal dichalcogenides (TMDs) are under investigation due to some promising electrical characteristics, such as an inherent band gap and a relatively high mobility of charge carriers, exhibited at nanoscale on single grains or islands.
Atomic Force Microscopy (AFM) offers a platform for the simultaneous characterization of multiple properties of 2D materials. AFM allows to determine the structural conformation and growth of 2D materials and probe their local electrical response. We used AFM to perform this kind of correlative microscopy on MoS2 layers grown onto sapphire via Metal Organic Chemical Vapor Deposition (MO-CVD). The morphological and electrical properties of samples with different thickness were studied and compared by using Conductive AFM.
It is known that water contamination strongly affects the properties of MoS2, because it leads to a p-doping of the material. In order to assess the effect of water on the conductive properties of MoS2, AFM measurements were done both in air and in high vacuum using a Park HiVac AFM system. The vacuum allows to get rid of the water layer naturally present on the top of the sample in ambient conditions. Results showed a larger local conductivity in vacuum with respect to air. Moreover, conductivity maps in vacuum showed an increased sensitivity with respect to measurements in air, allowing to determine boundaries between different conductive grains.
The ability of AFM to resolve electrical properties at nanoscale and the current advancement of the AFM technology, which allows integrating these characterization tools into the semiconductor manufacturing process, make AFM the ideal platform for the study of these 2D semiconductor materials.

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