From crafting to visualization: low-dimensional TMD nanostructures under the electron microscope lamppost

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One of the driving forces of the ongoing nanotechnology revolution is the ever-improving ability to understand and control the properties of quantum matter down to the atomic scale. Key drivers in this revolution are quantum materials, such as the two-dimensional (2D) materials of the transition metal dichalcogenide (TMD) family. The realization of novel TMD-based devices relies heavily on understanding the relation between structural and electrical properties at the nanoscale. The ultimate goal is that of crafting TMD nanostructures in a way that makes possible the tailored control of their properties. In this talk, recent studies illustrating novel fabrication approaches of TMD nanostructures based on combining top-down and bottom-up methods will be presented. These allow to control the resulting geometries and material combinations, making possible the realization of novel functionalities such as metallic edge states arising in MoS_2 nanowalls and nanotubes, enhanced nonlinear response in vertically-oriented MoS_2 nanostructures, and surface and edge plasmons in WS_2 nanoflowers. I will emphasize the crucial role that cutting-edge transmission electron microscopy techniques play in these studies, together with that of machine learning techniques which make possible extract a wealth of novel information which would be lost otherwise.

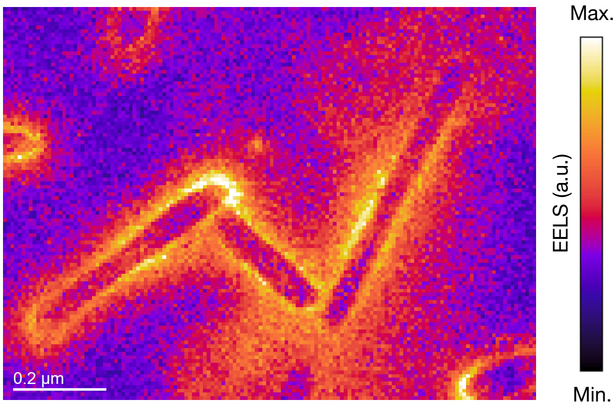

Figure 1. Experimental study of low-loss EELS acquired in MoS_2 nanotubes. Intensity map of the EELS signals integrated for a energy-loss window between 1-2 eV.