Epitaxial Growth of Single-Orientation High-Quality MoS_2 Monolayers on Au(111)

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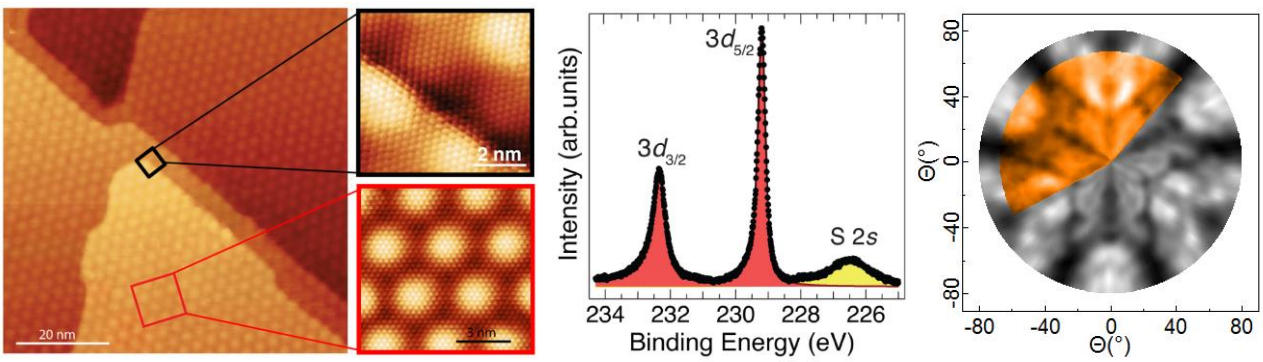
Monolayer (ML) transition metal dichalcogenides (TMDCs) and in particular MoS_2 have attracted widespread research interest due to their optical and electronic properties. However, their employment for electronic devices demands for a controllable growth of highly crystalline layers featuring large area with a low concentration of defects to preserve their outstanding electronic properties. Moreover, thanks to the peculiar electronic structure, new degrees of freedom are accessible allowing for spin- and valley-dependent phenomena, that can be retained in devices only through singly-oriented domains. Current chemical vapor deposition techniques have not been able to achieve this and have produced mirror twin domains leading to the formation of domain boundaries and dislocations in the layer.

We report on a protocol for the synthesis through physical vapor deposition of ML MoS_2 on Au(111) with a single domain orientation that can be, in principle, extended to other TMDCs and substrates. We demonstrate the structural properties using a combination of surface science techniques, including scanning tunneling microscopy (STM) and x-ray photoelectron diffraction (XPD). Angular resolved photoemission measurements (ARPES) confirmed the single layer character and the high structural quality of MoS_2 while the single domain orientation allowed the measurement, through Spin-resolved ARPES, of the complete spin polarization with spin reversal of the states near K and -K points.



(left) STM topography acquired on a large area and the corresponding zoomed-in regions. (center) Mo 3d core level spectrum with the resulting fit (line) and the fitted components (solid areas). (right) Experimental XPD pattern for the Mo 3d5/2 peak (orange area) in comparison with simulations.