Multi-scale analysis of epitaxially grown WSe_2 monolayer using advanced electron microscopy

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The development of growth methods, which allow a precise structural control, is an important issue to explore the extraordinary properties of transition metal dichalcogenides (TMDs). For instance, the grain size influences electric transport in TMD layers [1] and the atomic defects, such as vacancies and grain boundaries, can strongly affect their local electronic and magnetic properties [2]. Today a variety of analytical methods can provide lots of structural information on atomically thin layers from millimetre down to atomic scales, thanks to the evolution of technical capability and the advance in the scientific knowledge. Especially, aberration corrected transmission electron microscopy (AC-TEM) has become the most powerful technique giving precise local structural information such as vacancies and dislocations, which provides an insight on potential material properties.

In this work, we demonstrate a multi-scale analysis of WSe_2 monolayer grown by molecular beam epitaxy (MBE) in van der Waals regime [3], using a simultaneous real and reciprocal space imaging, so-called 4D-STEM, allowing to directly relate precise local atomic scale structural information with other analysis performed in large scale, in particular X-ray diffraction. The grain orientation distribution and resulted atomic scale defects are studied and the growth mechanism is finally discussed.

References

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[2] Z. Lin and al, 2D Mater,3(2016) 022002
[3] C. Vergnaud, M. Dau, B. Grevin, C. Licitra, A. Marty, H. Okuno, M.Jamet, Nanotechnology 31 (2020) 255602

Figures

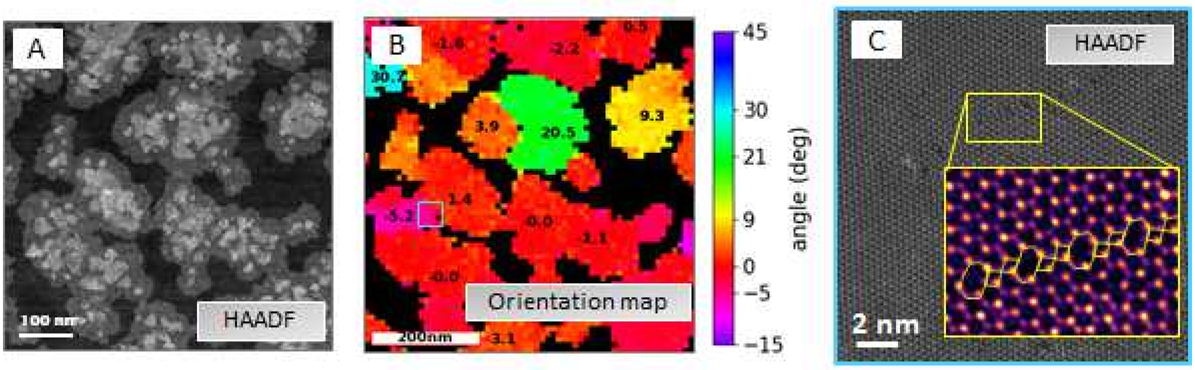

Figure 1: (a) HAADF image of WSe2 grains and (b) associated orientation map obtained by 4D-STEM and (c) HR HAADF image of grain boundary in a blue square in (b)