Study of the van der Waals epitaxy of WSe_2 on mica

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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].

In this work, we report the van der Waals epitaxial growth of WSe_2 on mica using the molecular beam epitaxy (MBE) technique. The growth was studied, from grains nucleation to their coalescence, to achieve large-scale WSe_2 with well-controlled atomic structure. Atomic force microscopy (AFM), X-ray diffraction (XRD) and Transmission electron microscopy (TEM) (Fig.1) were used to study the structure of WSe_2 layers by varying the growth temperature and W deposition rate in a broad range[3]. First, the crystal orientation of individual domains formed at early stage were analysed. The aim is to promote the epitaxial nucleation on the mica surface in order to obtain individual domains with the same crystal orientation, and a large-area single crystalline layer after their coalescence. Combining the optimal substrate surface treatment and experimental parameters, we obtained a large number of domains oriented in a favoured direction with small angle in-plane rotational mis-orientation, which are identified by DF imaging and XRD. Atomic scale TEM analysis revealed different types of grain boundaries (GB) and dislocations after their coalescence which formed as a consequence of inversion symmetry and slight in-plane mis-orientation between the neighbouring crystals (Fig.1). The epitaxial relationship at the van der Waals interface between WSe_2 and mica and the structural reconstruction at GBs will be discussed. The crystal quality was confirmed by an intense photo-luminescence (PL) emission at room temperature

This work provides insight into the MBE growth mechanisms of TMD monolayers to develop a new process to obtain large-scale TMD materials with well-controlled atomic structure.

References

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Figures

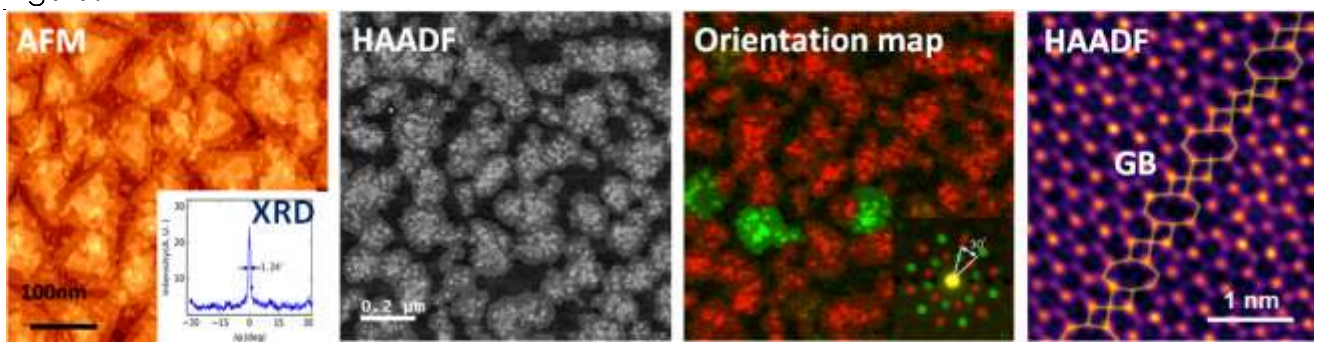

Figure 1 : Overview of WSe_2 domains grown on mica imaged by AFM, HAADF and 4D-STEM (orientation map). The atomic resolution image shows the formation of 4-8 based GBs between inversion symmetry domains.