Epitaxial synthesis of WS_2

Francesco Reale, Chiara Grotta, Cecilia Mattevi

Materials Department, Imperial College London, SW7 2AZ, UK
f.reale13@imperial.ac.uk

The chemical vapour deposition (CVD) of layered transition metal dichalcogenides (TMDs) holds promise for the synthesis of monolayered material over large areas with high structural quality for integration in optoelectronic devices. However, the synthesis of TMDs, and especially of WX_2 materials is still challenging since film continuity and thickness uniformity are often limited to tens of micron-sized areas. We have studied the CVD synthesis mechanism in low vacuum demonstrating formation of single layered WS_2 over hundred of micron-sized areas. We investigated the synthesis form the early stages of nucleation up to formation of a continuous films onto different substrates: epitaxial and amorphous.
Single layered films extended over large areas were obtained by optimizing the amount of metal oxide precursors, carrier gas flow rate and deposition temperature. Using a “boundary layer” model and taking into account the TX_2-substrate interaction, we have been able to provide a unified description of how different growth conditions can lead to different layer numbers and size and density of the nuclei. We show that different substrate interactions play a very important and counterintuitive role and we present a “phase diagram” of nuclei size and density as a function of the substrates properties. Optical and electrical properties are also presented and correlated with different interface characteristics.