Controlling oriented growth of wafer-scale transition metal dichalcogenides by MOCVD

Our research focuses on epitaxial growth of layered dichalcogenides, MX_2 (M=Mo, W and X= S, Se) by metalorganic chemical vapor deposition (MOCVD) using metal hexacarbonyl and hydride chalcogen precursors. A multi-step growth method was developed to achieve uniform, coalesced monolayer and few-layer TMD films on 2" sapphire substrates at growth rates on the order of ~1 monolayer/30 min. Controlling the growth temperature and chalcogen flux is crucial in establishing an epitaxial relation. Nuclei localization at the terrace edges, in addition to the underlying substrate, imposes a single orientation. Dark-field transmission electron microscopy of transferred WS_2 monolayers shows ~95% single orientation coverage with minimal bilayer and inversion domains. WS_2 single-crystal transferred films also show narrow exciton linewidths (~31 meV) and negligible defect-related emission at 80 K. The key features observed during the growth of WS_2, MoS_2 and WSe_2 will be discussed.

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