ABSTRACT:

Wafer-Scale Epitaxy and Layer Transfer of 2D Semiconductors

Metalorganic chemical vapor deposition (MOCVD) has emerged as a promising technique for wafer-scale synthesis of 2D semiconducting transition metal dichalcogenides (TMDs) for device applications. Two general approaches have been pursued: direct growth on oxide-covered substrates at BEOL-compatible temperatures or high temperature epitaxy on single crystal substrates followed by layer transfer. Our work has focused on the later approach with the goal of achieving wafer-scale single crystal TMD films that can be transferred and integrated at BEOL conditions. These efforts are illustrated for epitaxial growth of MoS_2 and WSe_2 on 50 mm diameter c-plane sapphire using metal hexacarbonyls and hydride chalcogen sources in either a H_2 or N_2 carrier gas. The epitaxial orientation of the TMD is found to be strongly dependent on growth conditions which can be tuned to minimize inversion domains and high angle boundaries as well as layer adhesion. Spectroscopic ellipsometry is demonstrated as a promising in situ monitoring tool for TMD growth, enabling real time measurements of monolayer and bilayer surface coverage enabling improved control of layer number as well as insights into the epitaxial growth process.