Epitaxial growth of transition metal dichalcogenides on sapphire for large area device applications

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Abstract

Wafer-scale epitaxial growth of semiconducting transition metal dichalcogenide (TMD) monolayers such as MoS_2, WS_2 and WSe_2 is of significant interest for device applications to circumvent size limitations associated with the use of exfoliated flakes. Epitaxy is required to achieve single crystal films over large areas via coalescence of TMD domains with the same crystallographic direction. The prospects and challenges associated with the epitaxial growth of wafer-scale TMD monolayers and heterostructures for the development of large area 2D devices will be discussed. Metalorganic chemical vapor deposition (MOCVD) has emerged as an enabling growth technology for TMDs due to its ability to achieve a combination of high growth temperatures (>700^{o}C) and large chalcogen overpressures which are needed to obtain stoichiometric epitaxial films. The unique aspects of van der Waals epitaxy of TMDs on sapphire substrates will be presented including the effects of crystallographic orientation of the substrate on nucleation density and domain orientation and the role of surface passivation and steps on domain alignment and defects. Techniques for wafer-scale 2D layer transfer for device integration will be reviewed and applications for wafer-scale TMD monolayers in nanoelectronics, sensing and photonics will be presented.