INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Layer-Controlled CVD Growth of 2D Tungsten Disulfide and Its Lateral Heterostructure with Molybdenum Disulfide for Optoelectronic and Biosensing Applications

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SHORT ABSTRACT

This thesis presents a comprehensive study on the layer-controlled CVD growth and multifunctional applications of WS_2, MoS_2, and in-situ WS_2-MoS_2 lateral heterostructures (HS). The 1L-WS_2 exhibited excellent PL emission at room temperature, which was employed as a sensitive tool for the selective detection of *Staphylococcus aureus* in PBS and urine samples. Functionalization of 1L-WS_2 with ssDNA aptamers enabled high selectivity, even in the presence of *E. coli*. For 2L-WS_2, photodetection performance was evaluated through asymmetric contact engineering using metals with work functions both lower and higher than that of 2L-WS_2, leading to unidirectional carrier flow. Compared to symmetric configurations, photodetectors (PDs) with asymmetric contacts demonstrated superior responsivity and detectivity. Thereafter, the influence of metal (Cr/Au) and non-metal (Bi_2Se_3) contacts on 1L-MoS_2 was investigated. Devices with ultrathin Bi_2Se_3 contacts exhibited cleaner contact interfaces with lower defect density, leading to improved performance, achieving an on/off current ratio of 10^8, two orders of magnitude higher than their metal-contacted counterparts. The flexible 1L-MoS_2 PD incorporating Bi_2Se_3 contacts also showed notable enhancements in responsivity, detectivity, and external quantum efficiency. Controlled in situ growth of WS_2-MoS_2 lateral HS was achieved by tuning the CVD growth parameters, enabling modulation of the relative areas of MoS_2 and WS_2 domains within single flakes. The diffuse interface induced interfacial strain, resulting in a fivefold increase in PL intensity from 2L-WS_2 near the junction. When integrated as channels in back-gated FETs, these HSs demonstrated superior electrical performance, including enhanced on/off ratios and improved subthreshold swings. Finally, WS_2 quantum dots (QDs), coupled with Bi_2O_2Se nanosheets, were utilized for the selective detection of *S. aureus*. The QDs, functionalized with ssDNA aptamers, enabled detection even in the presence of other analytes.

Overall, this thesis highlights the promising applications of WS_2-based materials in advanced electronics, flexible devices, and biosensing platforms.