Supplementary Material

Different types of band alignment at MoS\(_2/(\text{Al, Ga, In})\text{N}\) heterointerfaces

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The FWHM values of MoS$_2$/InN is the highest, followed by MoS$_2$/AlN, and the value for MoS$_2$/GaN is the least, thus indicating that growth quality of MoS$_2$ on GaN is best among the three (Fig. S1).

FIG. S1. Peak fitting of the two Raman modes of MoS$_2$ in different MoS$_2$/III-nitrides. The FWHM (w) values of the corresponding spectra have been shown along (marked by a red rectangle).

The AFM images of the top surface of MoS$_2$/(Al, Ga, In)N are shown in Fig. S2. It can be seen that the MoS$_2$ films are quite smooth, with some particulate formation in all the three samples. The root mean square (rms) surface roughness values for MoS$_2$/AlN, MoS$_2$/GaN, and MoS$_2$/InN are found to be 0.571, 0.501, and 1.26 nm, respectively.
FIG. S2. AFM scans of top surface of different MoS2/III-nitrides. The RMS roughness ($R_q$) values of the corresponding surfaces have been shown along (marked by a red rectangle).
The band offsets for different MoS$_2$/III-nitrides determined by HRXPS measurements are shown in Fig. S3.

FIG. S3. For MoS$_2$/InN: (a) Mo3d core level and valence band spectra acquired from MoS$_2$, (b) In3d and Mo3d core level spectra of MoS$_2$/InN heterojunction, (c) In3d core level and valence band spectra of InN epilayer; for MoS$_2$/GaN: (d) Mo3d core level and valence band spectra acquired from MoS$_2$, (e) Ga2p and Mo3d core level spectra of MoS$_2$/GaN heterojunction, (f) Ga2p core level and valence band spectra of GaN epilayer; and for MoS$_2$/AlN: (g) Mo3d core level and valence band spectra acquired from MoS$_2$, (h) Al2p and Mo3d core level spectra of MoS$_2$/AlN heterojunction, (i) Al2p core level and valence band spectra of AlN epilayer. Peak positions are marked in the parentheses.
**Figure S4** is a schematic of the comparison of band alignments of MoS$_2$ with different III-nitrides obtained from the above HRXPS results.

(a) MoS$_2$/InN, (a) MoS$_2$/GaN, (c) MoS$_2$/AlN, and (d) schematic of band alignments of MoS$_2$ with the III-nitride semiconductors (All energy values are in eV).

FIG. S4. Band alignment at (a) MoS$_2$/InN, (a) MoS$_2$/GaN, (c) MoS$_2$/AlN, and (d) schematic of band alignments of MoS$_2$ with the III-nitride semiconductors (All energy values are in eV).