Supplementary Information for
Selective and confined growth of transition metal
dichalcogenides on transferred graphene

Fei Lu, Arka Karmakar, Simran Shahi, and Erik Einarsson
Figure S1: Additional optical micrograph of MoS$_2$ on patterned graphene. Scale bar corresponds to 20 µm.

Figure S2: Raman spectrum of MoS$_2$ on graphene ranging from bilayer to bulk (5+ layers).
Figure S3: Statistical dispersion of Raman peak positions based on fitting of multiple ($N = 24$) MoS$_2$-on-graphene Raman spectra. Cross indicates mean position, box indicates the upper and lower quartiles, and the whiskers denote the standard deviation. Circles indicate outliers.
Figure S4: Left panel: Raman spectra of MoS$_2$ grown on graphene. Right panel: Raman spectra of MoS$_2$-on-graphene after annealing in sulfur environment at 900 °C. Spectra in left and right panels were taken at the same positions.
Figure S5: Box plot of Raman G peak position at different stages of WS$_2$-on-graphene growth process. Upshift indicates doping level, which is significant for graphene after WS$_2$ CVD, but not covered by WS$_2$. $N = 12$

The graphene G peak shifts when doping level in graphene increases. Therefore, the G peak position can be used to determine the doping level of graphene qualitatively. These spectra show graphene is more p-doped after transfer from copper to silicon substrate. However, the doping level of WS$_2$-covered graphene after CVD of WS$_2$ is only slightly higher than graphene transferred onto silicon. The doping level of graphene not covered by WS$_2$ after CVD is much higher than the graphene covered by WS$_2$. 
Figure S6: Onset of fluorescence tail near 3000 cm\(^{-1}\) offer additional evidence that identification of monolayer WS\(_2\) is correct.

The origin of fluorescence tail is the direct band gap in monolayer (ML) WS\(_2\). Because there is an energy difference between the 488 nm laser source and the ML WS\(_2\) band gap, a broad fluorescence peak can be generated around 4700 cm\(^{-1}\). The tail of this peak can be found seen near 3000 cm\(^{-1}\) in Raman spectra.

Emission is quenched in bilayer WS\(_2\) on silicon, because the direct band gap in ML WS\(_2\) is replaced by an indirect band gap. Emission is also quenched for ML WS\(_2\) on graphene, due to the fast charge transfer to graphene.\(^{[S1]}\)
References