Aluminum-Rich Reconstructed Sapphire as a High-Quality Growth Substrate for Tungsten Disulfide Synthesis

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Chemical Vapor Deposition (CVD) is the most important method in the large-scale synthesis of two-dimensional materials, and one of the most important aspects of CVD synthesis of 2D materials is the quality of the growth surface. Typically, monolayer TMD synthesis is limited on dielectric substrates due to the reactivity of metallic substrates with chalcogen precursors. Here we present a growth of tungsten disulfide (WS_2) on a sapphire surface annealed in hydrogen (H_2) to form an aluminum-rich surface reconstruction on to provide a better growth substrate for the synthesis of WS_2. [1] This approach has been used previously for graphene synthesis, [2] and is gaining traction as a growth substrate for TMDs, [3,4,5] although its use as a growth surface for TMDs has not been studied in detail. We confirmed the presence of the reconstruction by conducting LEED measurements on H_2-annealed sapphire prior to synthesis of WS_2. Using the Al-rich reconstructed substrate was found to significantly enhance the WS_2 growth, increasing the crystal size by 50 % and the nucleation density by 125 %. The crystals were characterized using correlated Raman and photoluminescence spectroscopies, AFM and KPFM, and the results revealed a high coupling of the WS_2 crystals with the Al-rich sapphire surface, which in turn helps to explain the higher catalytic activity of the Al-rich surface, as well as the observed differences in optical properties between normal and Al-rich sapphire substrates, exemplified in Figure 1.
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References

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Figures

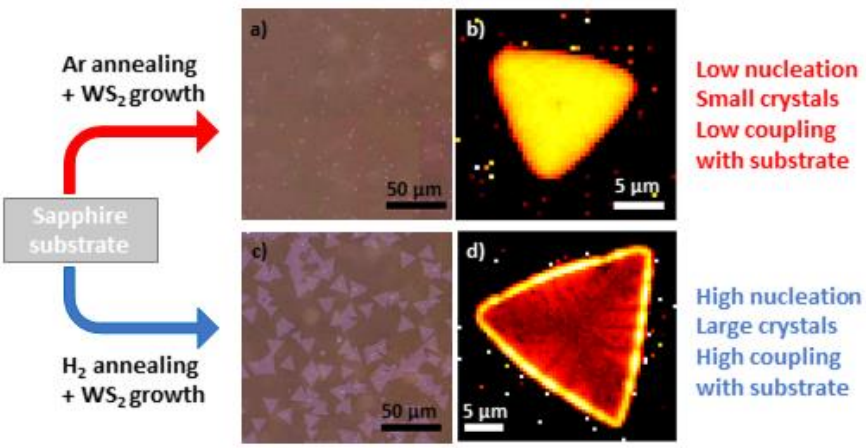

Figure 1: Optical microscope images and photoluminescence intensity maps of WS_2 grown on normal sapphire (a,b) and Al-rich reconstructed sapphire (c,d).