Scalable growth of atomically-thin MoS_2 layers in conventional MOCVD system using molybdenum oxychloride as the molybdenum source

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To bring atomically-thin transition metal dichalcogenides (TMDs) to practical application, a highly reproducible process to grow them over a large scale is indispensable. Metalorganic chemical vapor deposition (MOCVD) typically fulfills the requirement, but the used metalorganic precursors in MOCVD of TMDs inevitably introduce carbon contamination, resulting in degraded film quality.

In this work, we develop a carbon-free highly reproducible route for the scalable growth of high-quality monolayer MoS_2 by pioneeringly selecting molybdenum oxychloride (MoO_2Cl_2) as the Mo source and uniquely integrating the precursor with a standard well-controlled MOCVD system. Specifically, combing with H_2S as the sulfur source and using catalytic Dragontrail glass (DT-glass) as the main substrate, we investigate the effect of MoO_2Cl_2 flux, temperature, and deposition time on the growth and confirm MoO_2Cl_2 with reasonably high vapor pressure could be well compatible with MOCVD system, enabling precise control of source for uniform nucleation and growth of MoS_2 over a large area. Benefiting from this, we successfully demonstrate the growth of carbon-free MoS_2 monolayers on DT-glass with decent crystalline, optical, and electrical properties. Additionally, our initial attempts have also confirmed the growth of ultrathin MoS_2 layers on other technologically-important substrates (e.g., SiO_2/Si and quartz) is possible using the proposed method, where MoS_2 exhibits superior optical quality and wafer-scale uniformity. This work provides a new avenue for the large-scale production of high-quality MoS_2 monolayers and facilitates their use in practical applications. More discussion will be given at the conference.

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