Direct visual observation of 2D transition metal dichalcogenide growth

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Mono- and few-layer transition metal dichalcogenides (TMDs) attract increasing attention due to their interesting semiconducting and optoelectronic properties and corresponding advantages over semimetallic graphene [1]. Typical preparation methods of high-quality samples are mechanical exfoliation and chemical vapor deposition (CVD). Work with TMDs is made easy by the fact that on SiO2 covered silicon, monolayer and few layer samples are clearly visible due to interference effects [2]. In this work we show that this effect persists at typical CVD growth temperatures of 700-900 degrees C and flakes are still visible if external illumination is stronger than the black body radiation. We designed miniaturized CVD system with optical access for real time microscopy that enables observation of TMDs during growth. This makes possible direct observation and measurement of nucleation and growth rates, morphology evolution, in situ etching and changes during cooling, which leads to quicker and easier optimization of growth conditions and recipes. Grown MoS2 and WS2 single layers, and vertically stacked bilayer heterostructures are further characterized by atomic force microscopy, Raman spectroscopy and photoluminescence emission to confirm their thickness and quality.

[1] Q. Wang, et al., *Naure Nanotechnology* **7**, 699 (2012).
[2] M. Benaumer, et al., *Nanotechnology* **22**, 125706 (2011).