Controlled CVD synthesis of single- and few-layered MoS_2 crystals

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Two dimensional MoS_2 has been intensively studied over the past few years due to its excellent mechanical, electrical and optical properties [1]. Reliable and efficient wafer-scale CVD production methods are prerequisite for the fabrication of 2D-MoS_2 based devices. A variety of scalable CVD routes to fabricate 2D-MoS_2 have been proposed in the past with the most common involving the sulfurization of MoO_3 [1]. Taking place in atmospheric pressure and requiring only MoO_3 and elemental sulfur as precursors, it is by far one of the simplest methods used to fabricate 2D-MoS_2. Yet, one of its main disadvantages is that the uniformity and nucleation density of the produced crystals is difficult to control. Although other synthetic routes that offer a greater degree of control exist, they tend to be more complex requiring low pressure systems and potentially more expensive or even toxic precursors such as H_2S [2,3].

In this work we show that it is feasible to fabricate single- and few-layered MoS_2 crystals in a simple, one-step atmospheric pressure CVD synthesis using Na_2MoO_4 and elemental sulfur as precursors. Na_2MoO_4 is widely available, water soluble and relatively safe, commonly used as a fertilizer. The thickness and size of the crystals can be controlled by the deposited amount of Na_2MoO_4 precursor. The fabricated crystals are studied by means of X-ray photoelectron spectroscopy, atomic force microscopy, micro-Raman and micro-photoluminescence spectroscopies, and are compared with single-layer 2D-MoS_2 crystals that were exfoliated or transferred to other substrates. Through this comparison various spectral differences are found to arise from residual mechanical strain and/or doping levels induced by the interaction with the supporting substrate as well as the fabrication procedure. These strain and doping levels are quantified using an optical analysis published recently [4].

Figures

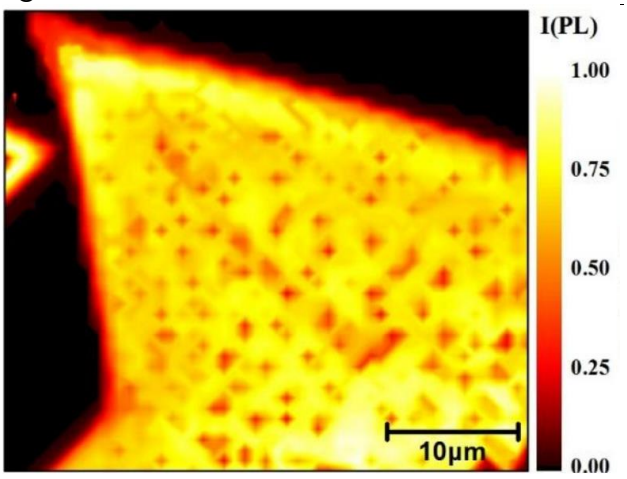

Figure 1 Photoluminescence intensity image of a CVD MoS_2 monolayer. The dark spots are few-layered seed crystals. The average photoluminescence peak position for the monolayer is 1.80(2) eV.

References

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