Atomically of MoS$_2$ thin layers via a two step thermal evaporation - exfoliation method

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Electronic Supplementary Information

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ESI.1 AFM Images

Fig. S1 A flake made of 8 layers. A one layer step on the top of the 8th layer can be resolved.
ESI.2 Proposed Reaction Mechanisms

At the lower temperatures of 775 °C, MoO$_3$ has been reduced to MoO$_2$ as the evaporated sulphur interacts with oxygen atoms of MoO$_3$ to produce SO$_2$, which is extracted as a gaseous by-product. At the higher temperature of 830 °C a mixture of MoS$_2$ and MoO$_3$ is obtained as the sulphur replaces the oxygen in MoO$_2$. This leads to the decrease in the percentage of gaseous sulphur which makes the annealing atmosphere less of a reduction environment. The replaced oxygen ions at higher temperatures along with the lack of sulphur allow a fraction of MoO$_2$ to re-oxidize back to MoO$_3$. Similar interactions have been reported by Ressler et al.$^{30}$ in a study of the formation of sub Mo oxides from MoO$_3$ in a reducing (H$_2$) environment. The proposed reaction mechanisms at 830 °C provide an overview of the composition of the end-product in relation to the initial ratio of reactents.

Proposed reaction mechanism at 775 °C:

$$2\text{MoO}_3 + S \rightarrow 2\text{MoO}_2 + \text{SO}_2$$

Proposed reaction mechanism at 830 °C:

$$\text{MoO}_2 + 3S \rightarrow \text{MoS}_2 + \text{SO}_2$$

$$3\text{MoO}_2 + 2S \rightarrow \text{MoS}_2 + 2\text{MoO}_3$$