An effective approach to synthesize monolayer tungsten disulfide crystals using tungsten hexachloride

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The transition metal dichalcogenides (TMDs) based layered materials (MoS$_2$, WS$_2$ etc.) have attracted significant interest as two dimensional (2D) semiconductor with a direct band gap. Recently, WS$_2$ has gaining a lot of attention and it is constructed with a sandwich of two atomic layers of S and one atomic layer of W through covalent W–S bonds, respectively [1]. Here, we demonstrate a process to control the nuclei for growth of large WS$_2$ crystals by solution-casting the WCl$_6$ precursor on substrate.

In the developed process, a 0.05M solution of WCl$_6$ was drop-casted on the substrate, which was loaded in the center of small diameter tube sealed at one-end. A boat with 200 mg of S powder was placed in the center of low temperature furnace. Sulfurization experiments were performed at a temperature of 750 °C in 80 sccm Ar atmosphere. Finally, the furnace was cooled down to room temperature and samples were removed from the tube.

We observed the growth of triangular (more than 50 µm), star-shaped WS$_2$ crystals. Figure 1a shows a triangular monolayer WS$_2$ crystal of 50 µm size. Figure 1b shows a six pointed star-shaped crystal. Figure 1c shows an AFM image of the as-synthesized WS$_2$ crystal on SiO$_2$/Si substrate. Line profile at the edge revealed an approximate thickness of around ~0.9 nm, which is almost comparable to monolayer WS$_2$ crystal.

![Figure 1](image1.png)

Figure 1 (a,b) FE-SEM images of triangular monolayer and six-arm star-shaped WS$_2$ crystal. (c) AFM image and line profile of the as-synthesized WS$_2$ crystal on SiO$_2$/Si substrate.

References