Chemical Vapor Deposition of 2D Transition Metal Dichalcogenides – Just Add Salts

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Chemical vapor deposition (CVD) of 2D transition-metal dichalcogenides (TMDCs) usually involves the conversion of vapor precursors into solid products via a vapor-solid-solid (VSS) mode (WO_3 + S/Se + H_2 → WS_2/WSe_2). It always requires an extremely high temperature and low pressure to sublimate the transition metal oxides.

In 2015, we published a pioneering work on halide-assisted atmospheric-pressure CVD of WSe_2 and WS_2 monolayers at lower temperature due to the formation of volatile tungsten oxychlorides (WO_3 + NaCl → WO_xCl_y, WO_xCl_y + S/Se + H_2 → WS_2/WSe_2).[1,2] This method has been widely used for growing ~ 50 types of 2D TMDCs in the last four years.[3]

In 2018, we revealed the important vapor-liquid-solid (VLS) growth of TMDCs which is triggered by the alkali cations in salt-assisted CVD (MoO_3 + NaCl → $Na_2Mo_xO_y$, $Na_2Mo_xO_y$ + S → MoS_2). The in-situ generated non-volatile Na-Mo-O droplets mediate the growth of 1D MoS_2 nanoribbons on NaCl crystal and 2D MoS_2 film.[4]

The VLS growth involves non-volatile molten precursors (e.g., Na_2MoO_4, Na_2WO_4) shows great advantages in wafer-scale growth of 2D TMDC film and patterned (site-controlled) growth of 2D TMDC monolayers.[5] We clarified that the VLS growth thus pave the new way for the high-efficient, scalable synthesis of two-dimensional TMDC monolayers. It opens a new research direction for the 2D community.

References

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