A Universal Strategy for Synthesis of 2D Ternary Transition Metal Phosphorous Chalcogenides

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The 2D ternary transition metal phosphorous chalcogenides (TMPCs) have attracted extensive research interest due to their widely tunable band gap, rich electronic properties, inherent magnetic and ferroelectric properties. However, the synthesis of TMPCs via chemical vapor deposition (CVD) is still challenging since it is difficult to control reactions among multi-precursors. Here, a subtractive element growth mechanism is proposed to controllably synthesize the TMPCs. Based on the growth mechanism, the TMPCs including $FePS_3$, $FePSe_3$, $MnPS_3$, $MnPSe_3$, $CdPS_3$, $CdPSe_3$, $In_2P_3S_9$, and $SnPS_3$ are achieved successfully and further confirmed by Raman, second-harmonic generation (SHG), and scanning transmission electron microscopy (STEM). The typical TMPCs–$SnPS_3$ shows a strong SHG signal at 1064 nm, with an effective nonlinear susceptibility $\chi^{(2)}$ of 8.41×10^{-11} m V^{-1}, which is about 8 times of that in MoS_2. And the photodetector based on $CdPSe_3$ exhibits superior detection performances with responsivity of 582 mAW^{-1}, high detectivity of 3.19×10^{11} Jones, and fast rise time of 611 μs, which is better than most previously reported TMPCs-based photodetectors. These results demonstrate the high quality of TMPCs and promote the exploration of the optical properties of 2D TMPCs for their applications in optoelectronics.

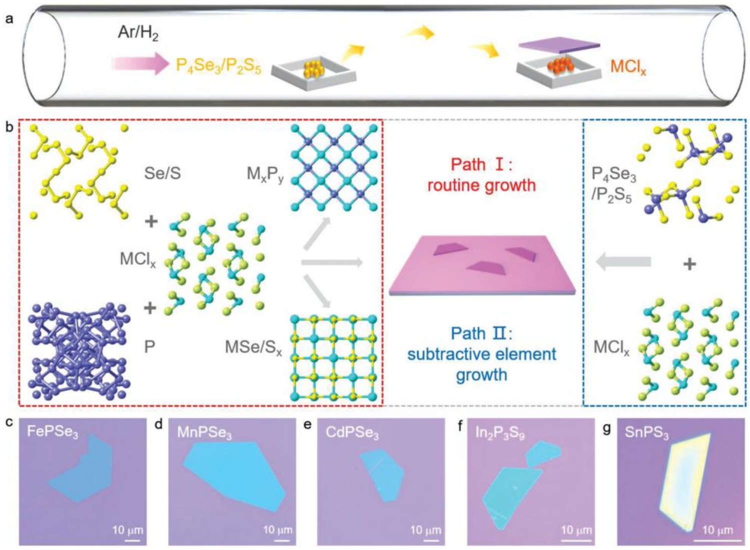

Figure 1. a) Schematic of the CVD process via subtractive-element-based growth strategy. **b)** The mechanism of routine and subtractive element growth. **c–g)** Optical images of the synthesized $FePSe_3$, $MnPSe_3$, $CdPSe_3$, $In_2P_3S_9$, and $SnPS_3$.

Bibliography

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[2] Zhou, J., Zhu, C., Zhou, Y. et al. Nat. Mater. 22, 450–458 (2023).