High-Mobility Multilayered MoS₂ Flakes with Low Contact Resistance Grown by Chemical Vapor Deposition

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Multilayered (ML) MoS₂ shows higher mobility than their single layered counterparts, but the controllable synthesis and contact engineering remain the key challenges to harvest their greatest potential. To realize the controllable growth of high quality ML MoS₂ and achieve the ultimate performance of 2D MoS₂, we developed a CVD approach for growing highly crystalline ML MoS₂ flakes with gradually shrinking basal planes from the bottom to the top layers. This unique geometry enables the direct contacts of each MoS₂ layer to the electrodes and therefore, the CVD-grown ML MoS₂ exhibits much higher mobility and current density than mechanically exfoliated ML MoS₂ and thus makes 2D MoS₂ more competitive for future electronics. Moreover, the atomic edge structures, stacking configuration and structure-properties dependence were also systemically investigated with various microscopic and spectroscopic characterizations and revealed that the MoS₂ layers were stacked in a well-defined AA order and terminated with atomically smooth Mo zigzag (zz)-edges. Besides their promising applications in high performance field-effect transistors (FETs) and rectifying diodes, these AA-stacked MoS₂ flakes showing broken inversion nature also hold great potential for fundamental studies on optical nonlinearity and valley physics.

References


Figures

Figure 1: Synthesis of MoS₂ flakes with varied layer numbers by the rapid sulfurization of electrochemically oxidized Mo foils in gas phase in a confined space

Figure 2: Electrical performances of the CVD-grown ML MoS₂ flakes. a, b) Schematic illustrations of the electrical contact geometries in ML exfoliated MoS₂ and CVD-grown MoS₂ flakes. c) $I_{ds}-V_{gs}$ and $I_{ds}-V_{ds}$ characteristics of a 16L MoS₂ flake. d) $I_{ds}-V_{ds}$ characteristics of 1L–8L MoS₂ junction measured at a gate voltage of 0 V. e, f) Statistics of electron mobility (e) and current measured at $V_{gs} = 40$ V and $V_{ds} = 1$ V (f) as the function of layer numbers in CVD-grown MoS₂ flakes (red columns) and mechanically exfoliated MoS₂ flakes (blue columns).