Phase selective growth of rhombohedral MoS_2 for optoelectronic applications

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The synthesis of materials with desired polymorphic phases in a chemical vapor deposition (CVD) process necessitates a meticulous balance among various thermodynamic variables. In this study, we present a methodology to synthesize rhombohedral (3R) phase MoS_2 in well-defined sword-like geometry, exhibiting lengths of up to 120 µm, uniform widths ranging from 2-3 µm, and thicknesses of 3-7 nm by precisely controlling the dynamics of carrier gas flow from continuous mode to pulsed mode during the CVD growth process. To validate the formation of the 3R phase material, we investigate its characteristic signatures. The resulting MoS_2 swords exhibit a high degree of circular dichroism (~58% at 100 K), accompanied by a distinctive evolution of low-frequency Raman peaks and an increasing intensity of second harmonic signals with increasing number of layers.[1] These findings conclusively establish the presence of the 3R phase in the material. Further, a field effect mobility of 40 cm^2/V-s and an I_{on}/I_{off} ratio of ~10^6 confirm the exceptional electronic quality of the 3R-phase MoS_2. These findings hold significant promise for the advancement of emerging quantum electronic devices, valley-based physics and nonlinear optical phenomena in layered materials.

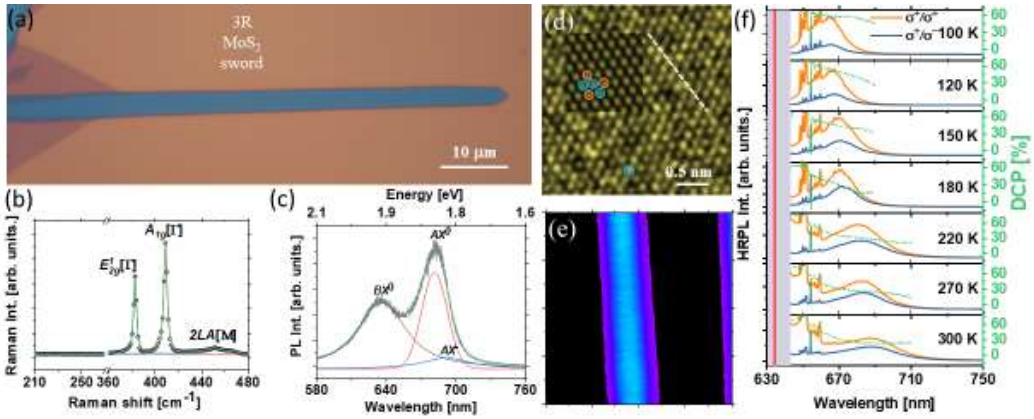

Figure 1. (a) Optical microscope image of 3R-MoS_2 grown on SiO_2/SI (b-c) Single point Raman and PL profiles of MoS_2 (d) High-resolution transmission electron microscopy image of MoS_2 (e-f) Second harmonic generation mapping and helicity resolved photoluminescence of MoS_2

References

[1] Ramesh R, Barman PK, Yadav R, Biswas R, Devaraj M, Poudyal S, Biswal B, Gupta VL, Pradhan G.K, Raghunathan V, Nayak PK, Misra A. ACS Nano 16, 12, 2022, 21366–21376