Optical and structural properties of ternary $MoWS_2$ grown by atomic layer deposition

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Molybdenum disulfide (MoS_2) and tungsten disulfide (WS_2) are members of the transition metal dichalcogenide material family. Two-dimensional (2D) monolayers of MoS_2 and WS_2 are semiconductors with a direct optical band gap of ~1.9 and ~2.0 eV, respectively. The similar crystal structures and lattice constants of both materials promise full miscibility of ternary $MoWS_2$ and no strain/relaxation induced defects and phase separation issues are expected. Depending on the concentration x in $Mo_xW_{1-x}S_2$ it is possible to tune the exciton transition energy [1].

In this work, atomic layer deposition (ALD) was used for the growth of monolayer MoS_2, WS_2 as well as $(Mo,W)S_2$ in different compositions on a SiO_2/Si substrate. ALD uses a pulsed precursor supply, i.e. the S, Mo and/or W precursors are provided separately during the growth process to enable the chemical reaction between the absorbed precursors on the surface only. Raman spectroscopy and scanning transmission electron microscopy (STEM) allow to investigate the homogeneity of the distribution of Mo and W atoms in monolayers depending on the number and sequence of alternating pulses for ALD growth.

$Mo_xW_{1-x}S_2$ monolayers were grown with different concentrations in the whole composition range from x=0 to x=1. Raman and photoluminescence (PL) investigations show a concentration dependent shift of the A_{1g} mode (Figure 1a) and the recombination energy of the A and B exciton (Figure 1b), respectively. The distribution of Mo and W atoms in the $MoWS_2$ layer with different concentrations is studied by TEM. It is shown that clustering of Mo and W appears for concentrations close to binary MoS_2 and WS_2 due to the pulsed precursor scheme.

References

[1] N. Mutz, T. Meisel, H. Kirmse, S. Park, N. Severin, J. P. Rabe, E. List-Kratochvil, N. Koch, C. T. Koch, S. Blumstengel, S. Sadofev, Appl. Phys. Lett. **114**, 162101 (2019).

Figures

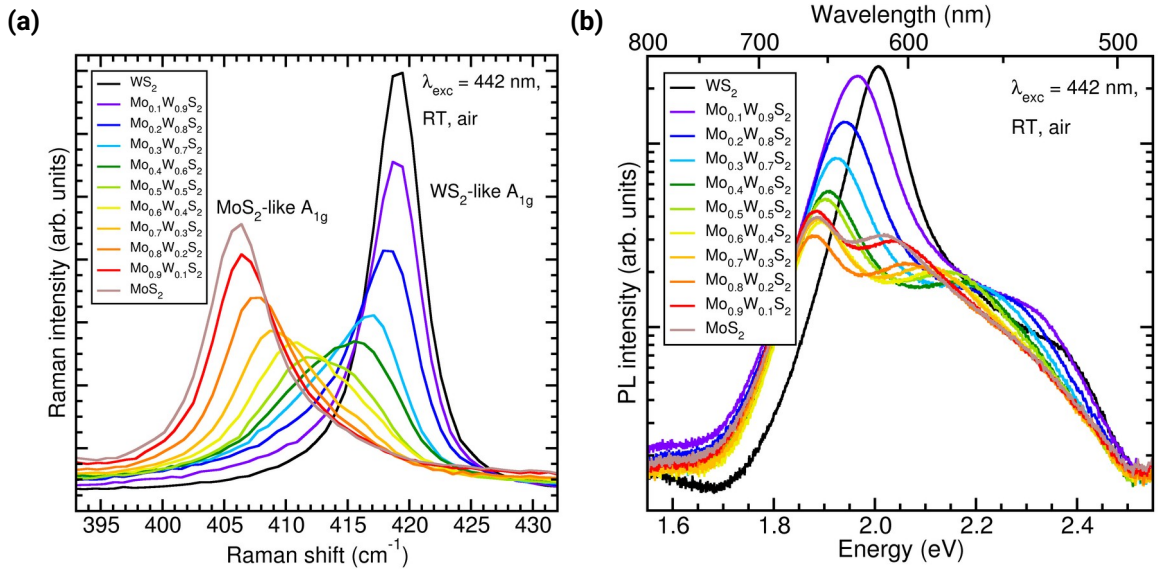

Figure 1: Raman spectra (a) and PL spectra (b) of $Mo_xW_{1-x}S_2$ monolayers with different concentrations.