Aktuelle Fragen
der Nanophysik

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Mastering MoS_2: Unlocking the role of synthesis in electronic and optical properties

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Even though MoS_2 is among most investigated materials in the last 20 years, there are still unanswered questions regarding its electronic and optical properties. One of those questions is: to what extent synthesis parameters influence sample's properties?
In the last 4 years, I have done a systematic study of how synthesis parameters, such as precursor concentration, argon flow, sulphur and growth temperature influence electronic and optical properties of monolayer (1L) MoS_2 samples. These parameters are not mutually independent and, as will be shown, heavily influence the sample's morphology and optical properties [1]. Samples synthesised under optimum conditions are not only stable under atmospheric conditions, they can also withstand extreme environments such as broad temperature range (multiple cooling cycles from 4.2 K), solvents (water, glycerine) and high fluence laser sources.
The main part of my talk will be about microscopic investigation of intrinsic defects using a combination of non-invasive techniques: Kelvin Probe Force Microscopy (KPFM), temperature dependent photoluminescence (PL) and room temperature ultrafast transient absorption (TA) microscopy [2]. Using these techniques, I was able to correlate the synthesis parameters with the spatial distribution of intrinsic defects in as-grown 1L MoS_2 (Figure 1.). It was observed that the higher growth temperature results in a sample with homogeneous electronic and optical properties, with longer-lived charge carries, due to the lower defect concentration. On the other hand, sample synthesised at lower growth temperature has position dependent electronic and optical properties, and its charge carries have shorter lifetimes, due to increased defect concentration.
In the final part of my talk I will present ongoing projects which relate to modification of optical properties of monolayer TMDs using different strategies: doping, organic molecules and metallic systems, such as gold nanoparticles.

[1] A. Senkić, J. Bajo et al. Materials Chemistry and Physics **296** (2023) 127185.
[2] A. Senkić et al. Nanotechnology **34** (2023) 475705.

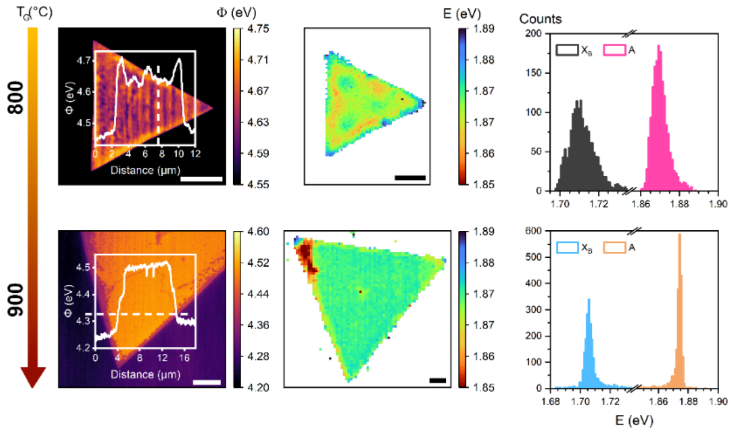

Figure 1. Comparison of electronic and optical properties in 1L MoS_2 grown at different temperatures: 800 °C (top row) and 900 °C (bottom row). KPFM maps are shown left column. Insets show the work function measured across the sample (work function line profile) denoted by the white dashed line. PL maps of A exciton energy taken at 4.2 K are shown in the middle column. The scalebar is 5 µm. Right column: energy distributions of A and bound excitons at 4.2K for the same samples.