Optical investigation of MBE–grown molybdenum diselenide monolayers.

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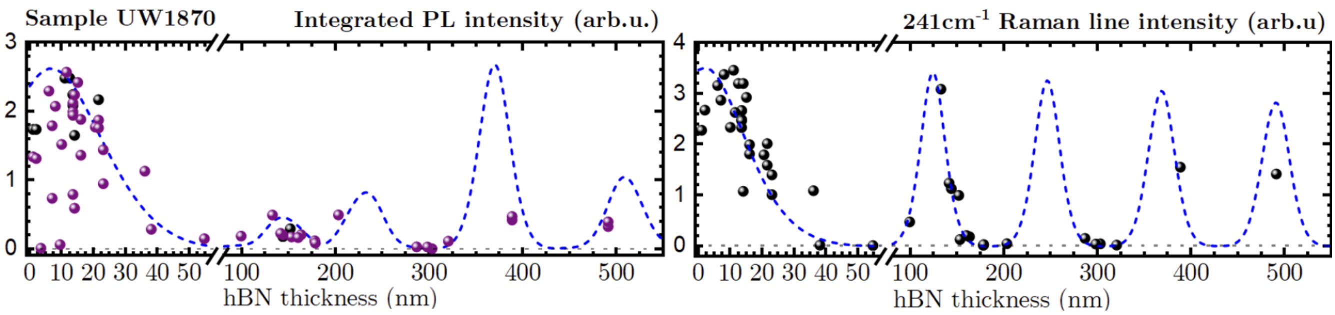
The growing interest in the physics of two-dimensional semiconducting layers has one major inconvenience. In most cases, studied systems are not, in fact, two-dimensional. Exfoliated flakes of transition metal dichalcogenides (TMDs) are relatively small and highly spatially inhomogeneous due to strains originating from the layer transfer process. On the other hand, the samples produced by the epitaxial techniques in a bottom-up approach show a supreme advantage of large-scale homogeneity and reproducibility.[1] Scalable methods give hope for them being applied in industry applications in the near future.

In our work, we investigate samples of monolayer $MoSe_2$ grown by molecular beam epitaxy on the manually exfoliated hexagonal boron nitride flakes that were deposited onto silicon–silicon oxide wafer. The samples we have obtained exhibit robust homogeneity not only on a scale comparable to single exfoliated h–BN flakes but, moreover, on the scales of the whole silicon dice. That fact was observed as the consistency of the low–temperature photoluminescence and room–temperature Raman scattering spectra measured at dozens of spots of different h–BN flakes. The energy, linewidth, as well as shape of the excitonic lines in PL spectra, remained very similar across each MBE–grown sample.

Although the PL spectra shape remained fairly, spatially unchanged, its intensity varied substantially within the given sample and between samples obtained in different growth processes. In this work, we explore the reasons standing behind the observed phenomena. By analysing the h-BN thicknesses and monolayer filling–factor with an atomic force microscope we were able to pinpoint the main differences affecting light emission intensity between $MoSe_2$ monolayer samples and to develop the interference model that explains PL and Raman scattering intensity as function of a below lying h-BN thickness.



[1] W. Pacuski, M. Grzeszczyk, K. Nogajewski, A. Bogucki, K. Oreszczuk, J. Kucharek, K. E. Połczyńska, B. Seredyński, A. Rodek, R. Bożek, T. Taniguchi, K. Watanabe, S. Kret, J. Sadowski, T. Kazimierczuk, M. Potemski, and P. Kossacki, *Nano Lett.* **20**, 5 (2020).