Engineering optical transitions in MoS_2 nanostructures

Bernhard Urbaszek
Université de Toulouse, INSA-CNRS-UPS, LPCNO, 135 Avenue Rangueil, 31077 Toulouse, France
urbaszek@insa-toulouse.fr

In the first part of the talk, we concentrate on transition metal dichalcogenide (TMD) layers grown by Chemical vapor deposition (CVD) over large surface areas on inexpensive substrates. We study the structural quality of CVD grown MoS_2 monolayers (MLs) on SiO2/Si wafers by high-resolution transmission electron microscopy (HRTEM). For optical spectroscopy, we remove the MLs from the SiO_2 growth substrate and encapsulate them in hBN flakes with low defect density, to reduce the detrimental impact of dielectric disorder. We show a reduction in optical transition linewidth from 50 meV (as grown samples) down to 5 meV at low temperature (T = 4 K) for the free excitons in emission and absorption, which allows studying fine details of exciton transitions and valley polarization [1].

Combining MoS_2 monolayers to form multilayers allows accessing new functionalities. We examine the correlation between the stacking order and the interlayer coupling of valence states in MoS_2 homobilayer samples grown by CVD and artificially stacked bilayers from CVD monolayers. We show that hole delocalization over the bilayer is allowed in 2H stacking and results in strong interlayer exciton absorption and also in a larger A-B exciton separation as compared to 3R bilayers, where both holes and electrons are confined to the individual layers. Comparing 2H and 3R reflectivity spectra allows extracting an interlayer coupling energy of about 50 meV. Obtaining very similar results for as-grown and artificially stacked bilayers is promising for assembling large area van der Waals structures with CVD material [2]. In addition to CVD grown layers we also incorporated exfoliated 2H MoS_2 bilayers in gated structures. We aim to combine the strong light-matter interaction of excitons in monolayers with high tunabilty of interlayer excitons in external electric fields in our experiments based on the quantum confined Stark effect [3].

These results are based on fruitful collaborations with FSU Jena, University of Basel, University of Ulm and NIMS Tsukuba.

References

[1] S. Shree *et al.* 2D Mater. 7 (2020) 01501
[2] I. Paradisanos, S. Shree *et al.* arXiv:2001.08914
[3] N. Leisgang, S. Shree, I. Paradisanos, L. Sponfeldner *et al.* arXiv:2002.02507

Figures

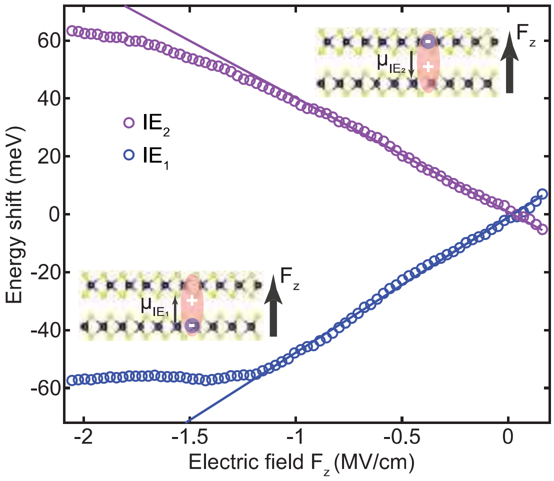

Figure 1: Splitting in absorption between 2 interlayer exciton configurations in homobilayer MoS_2