Jakob WIERZBOWSKI

Group of Prof. Jonathan Finley,
Walter Schottky Institute (WSI), Garching

1. Short CV

1987: born in Göttingen, Germany
2007-2012: studied Physics at Technische Universität München, Garching
2012: diploma in physics at Technische Universität München (on plasmonic nanostructures under Prof. Finley)
Since June 2014: ExQM PhD student in group of Prof. Jonathan Finley, Walter Schottky Institute, Technische Universität München

External collaborations:

Andor Kormányos - Universität Konstanz

2. PhD Project: "Optical studies on quantum nanosystems built from emergent two-dimensional transition metal dichalcogenides"

In the course of my PhD project, I was able to study various fundamental properties of emergent two-dimensional transition-metal dichalcogenides (TMDCs), such as MoS_2, $MoSe_2$ and WSe_2.
Being a van-der-Waals crystal and similar to graphene, a single monolayer of a TMD has a hexagonal structure and is bound by strong covalent bonds within a single layer. However, TMDCs consist of a monolayer of transition metal atoms sandwiched between two monolayers of chalcogen atoms. In the out-of-plane direction weaker van-der-Waals forces conciliate the interaction between neighboring layers.
Interestingly, these materials exhibit a direct bandgap (lowest lying energy difference between the ground and an excited state for electrons in solids) in the monolayer limit, where at low temperatures (10 K) excitonic effects dominate the optical properties.
In momentum space, the points of minimal energy difference lie at six distinct momenta (high symmetry K-points / K-valleys) due to their hexagonal crystal structure.
Me and my coworkers were able to build nanofabricated devices, that control the excitonic properties of mono- to multi-layer MoS_2 [1].
Since symmetry dictates the optical selection rules, we were able to change the polarization states of the optical emission from distinct K-valleys [2] and enhance non-linear light generation [3] via breaking of inversion symmetry using electric fields.
Building TMD heterostuctures by stacking different van-der-Waals crystals on top of each other, we were able to prolong the lifetime of defect induced quantum emitters in WSe_2 [3]. Our current studies concentrate on the electrical and coherent control of quantum emitters in 2D semiconducting monolayers of WSe_2.

Outlook:

I'm looking forward to a stay abroad at Stanford University. They possess various complementary experimental facilities having great potential conclude our understanding of the exciton dynamics inside TMD nanodevices.

Publications and preprints:

[1] J. Klein and J. Wierzbowski *et al.*, "Stark Effect Spectroscopy of Mono- and Few-Layer MoS_2", Nano Lett. **16**, 1554-1559 (2016)
[2] J. Wierzbowski and J. Klein *et al.*, "All electrical control of effective valley Zeeman-splitting in bilayer MoS_2", in preparation (2016)
[3] J. Klein and J. Wierzbowski *et al.*, "Giant electric-field switchable second-harmonic generation in bilayer MoS_2 by inversion symmetry breaking", in preparation (2016)
[4] J. Wierzbowski and J. Klein *et al.*, "Topology-induced quantum emitters in hBN/WSe_2 van der Waals heterostructures", in preparation (2016)

Presentations at conferences:

2015: CFP/NIM Workshop, Hong-Kong/China (Poster) "Control of valley polarization in few-layer MoS_2 by electric field induced symmetry breaking"

2015: EP2DS-21/MSS-17, Sendai/Japan, (Talk) "Tuning of valley polarization in few-layer MoS_2 by electric field induces symmetry breaking"

2016: 19^{th} International Winterschool, Mauterndorf/Austria (Poster) "Symmetry control of layered 2D semiconducting materials in novel nanodevices"

2016: CECAM-Workshop TM2DM, Bremen/Germany (Poster) "Long-lived quantum emitters in hBN-WSe_2 van der Waals heterostructures"