Two-dimensional crystals and their coupling to plasmonic nanostructures

Michael Kaniber

Walter Schottky Institut und Physik Department, Technische Universität München,
Am Coulombwall 4, 85748 Garching, Germany

Over the past few years atomically-thin materials, such as graphene, boron nitride and the group-VI transition metal dichalcogenides (TMDC), have stimulated intense interdisciplinary research in condensed matter physics, chemistry and electrical engineering. Due to their unique mechanical, electrical and optoelectronic properties they have already been implemented into flexible electronic and photonic devices such as high-performance field effect transistors, optical sensors, photo-catalytic and photo-voltaic devices and, most recently, light emitting diodes and lasers spanning the visible, infrared and THz regions of the electromagnetic spectrum.

In this talk, I will present studies on atomically-thin layered semiconductors, such as MoS_2 and $MoSe_2$, their integration into functional devices [1] and the control of the second-order non-linear response from MoS_2 bilayers by applying vertical dc-electric fields in SiO_2/Al_2O_3-microcapacitors [2]. Furthermore, I will elaborate on the influence of He-ion irradiation in a Helium ion microscope (HIM) on the optical, vibrionic and valleytronic properties of MoS_2 [3] and the potential application of HIM exposure in combination with TMDC heterostructures [4] for controlled defect engineering of single luminescence centres [5]. Moreover, I will present studies of coupling the spontaneous emission of monolayer $MoSe_2$ to the guided modes of nanoplasmonic slot-waveguides [6], where one observes clear evidence for waveguiding, paving the way towards a true nanoscale 2D crystal light on-chip source. Finally, if time permits, I will present first preliminary results on local photocurrent readout in such an electrically contacted nanoscale waveguide geometry [7].

Besides exploring and understanding fundamental light-matter-coupling in nanoscopic materials, the general aim of our group is to combine low-dimensional semiconductor quantum materials with deterministically fabricated nanoscale optical hardware for on-chip integrated nanophotonic applications.

[1] J. Klein *et al.*, Nano Lett. **16**, 1554 (2016)
[2] J. Klein *et al.* Nano Lett. **17**, 392 (2017)
[3] J. Klein *et al.* 2D Mater. **5**, 011007 (2018)
[4] J. Wierzbowski *et al.* Sci. Rep. **7**, 12383 (2017)
[5] J. Klein *et al.* in preparation (2017)
[6] M. Blauth *et al.* 2D Mater. **4**, 021011 (2017)
[7] M. Blauth *et al.* unpublished results (2017)