Strain-induced localization of interlayer excitons in a van-der-Waals heterostructure

Malte Kremser[1]
Mauro Brotons-Gisbert[2], Janine Gückelhorn[1], Moritz Meyer[1], Brian D. Gerardot[2], Kai Müller[1], Jonathan J. Finley[1]

[1]*Walter Schottky Institute, Technical University of Munich, Am Coulombwall 4, Garching, Germany*
[2]*Institute for Photonics and Quantum Sciences, SUPA, Heriot-Watt University, Edinburgh, United Kingdom*

Malte.Kremser@wsi.tum.de

Interlayer excitons (IX) in van-der-Waals heterostructures are currently subject to intense study [1-4]. For example, they constitute an interacting Bosonic system in the solid state whose properties can be widely tuned by electric fields [1], the choice of materials and the microscopic separation and rotational alignment of the individual layers. [2-4]. In this contribution we use local strain to localize IX in a WSe_2-$MoSe_2$-heterobilayer. Hereby, we place it onto a dielectric substrate patterned with arrays of 130 nm (width) x 90 nm (height) micropillars using viscoelastic stamping. Confocal luminescence measurements performed at low temperature (10 K) reveal clear IX emission around 1.37eV, that blueshifts by ~30meV upon increasing the excitation level over six orders of magnitude from 0.03 W/cm^2 to 50 kW/cm^2. In contrast, at the pillar sites the IX emission for the lowest excitation levels studied is accompanied by sharp line emission ~50 to 100 meV below the IX and attributed to localized IXs (denoted LIX on fig 1). Upon increasing the pumping level, additional emission peaks emerge in the vicinity of LIX. We identify these sharp emission features as arising from multiple, interacting IX localized within a local strain potential by excitation-power-dependent experiments (fig. 2). Our results provide information about exciton-exciton interactions within the strain potential.

References

[1] Rivera et al., Nat. Commun. 6, 6242 (2015)
[2] Tran et al., Nature (2019), DOI: 10.1038/s41586-019-0975-z
[3] Seyler et al., Nature (2019), DOI: 10.1038/s41586-019-0957-1
[4] Jin et al., Nature (2019), DOI: 10.1038/s41586-019-0976-y

Figures

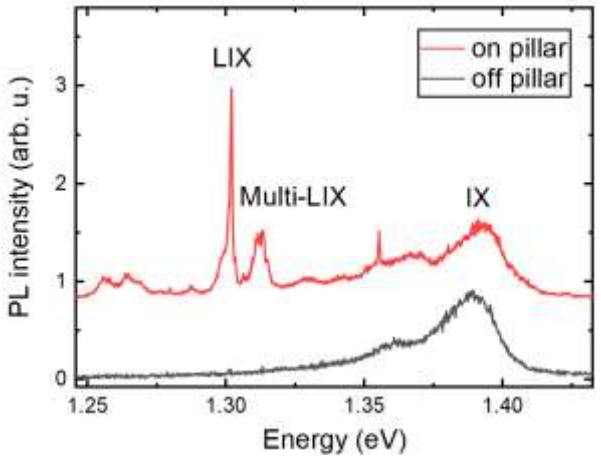

Figure 1: Low-temperature photoluminescence spectrum of a strained WSe_2-$MoSe_2$-heterobilayer at a pillar site. The spectrum features the characteristic IX emission at 1.39 eV (also present off pillar) and strongly red-detuned emission from localized interlayer excitons (LIX).

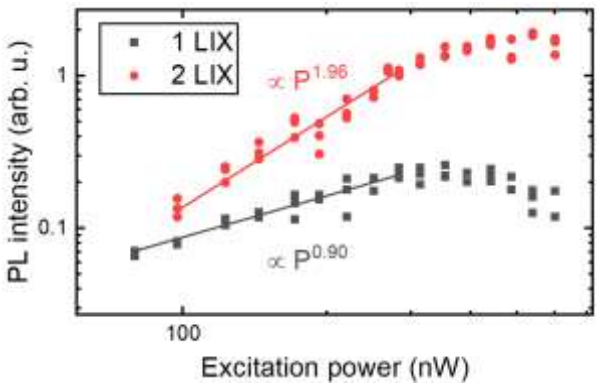

Figure 2: PL intensities of the localized single and double interlayer exciton as a function of excitation power. Before saturation, the characteristic linear and quadratic power dependence are observable.