Non equilibrium anisotropic excitons in atomically thin ReS_2

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Rhenium disulfide is a member of the family of rapidly emerging transition metal dichalcogenides. It has gained particular interest due to its environmental stability and pronounced in-plane anisotropy of the optical and electrical properties, stemming from the low symmetry of its distorted 1T' lattice [1,2].

Despite intensive investigation the character of the ReS_2 badgap still raises controversy. Here we show detailed investigations of the optical properties of ReS_2 flakes with a different number of layers which allowed us to conclude on the indirect character of the fundamental bandgap from bulk to monolayer. We observed linearly polarized photoluminescence from two non-degenerate excitonic states X_1 and X_2. The weak PL intensity as well as the simultaneous observation of X_1 and X_2 emission suggest hot-carrier nature of the photoluminescence and the presence of a lower indirect bandgap which provides a non radiative relaxation pathway. We discuss the experimental results in the light of DFT calculations and predictions of a model based on rate equations [3].

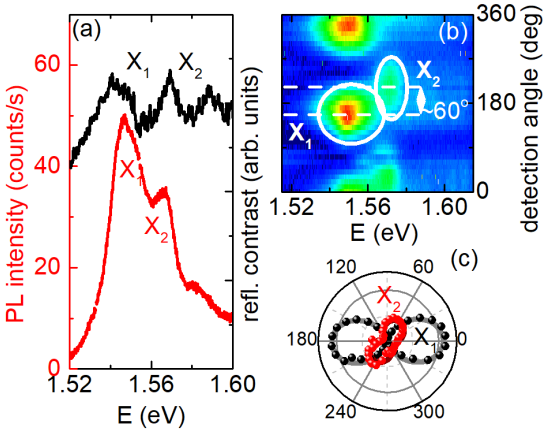

Figure 1: (a) PL and reflection contrast spectra of bulk-like ReS_2. (b) PL intensity as a function of the linear polarization detection angle. (c) Intensity of X_1 and X_2 emission as a function of polarization detection angle.

[1] O. B. Aslan, *et al.*, *ACS Photonics* **3**, 96 (2016).
[2] A. Arora, *et al.*, *Nano Letters* **17**, 3202 (2017).
[3] J. M. Urban, M. Baranowski *et al.*, *submitted* .