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Orientation of excitons in layered Rhenium disulfides

In the layered transition metal dichalcogenide (TMDs), optical anisotropies reveal a fundamental relationship between structural and optical properties.[1–2] Optical anisotropies in the materials, could be realized in the in-plane and out-of-plane dipoles which could be originated from the intra- and inter-layer excitations, respectively in he case of the layered TMDs. These directional optical properties are very intriguing to enhance the performance of modern optoelectronic devices.[3] Here, we first studied the origin of the exciton in the Rhenium disulfide (ReS_2) layers which is considered as a direct gap material even at bulk thickness and existed in the 1T' lattice phase. Secondly, we resolve the orientation of luminescent excitons of the ReS_2 and distinguish between in-plane and out-of-plane oriented excitons in the materials with weak inter-layer coupling-ReS_2 unlike the case of well understood molybdenum or tungsten based TMDs. We demonstrate that photo-luminescence from ReS_2 mono- and bi- originates mainly from in-plane excitons, whereas bulk like crystal supports distinct, in-plane and out-of-plane exciton species. Out of plane excitons were found to be existed at higher energy region with different spectra and dipole strengths at room temperature than in-plane spacies. The presence of in-plane and out-of-plane exciton photo luminescence signatures arising from distinct intra- and inter layer optical transitions in the same 1T'-ReS_2 crystal provided by this work is important for understanding fundamental excitonic properties in the layered nano-materials and designing optical systems that efficiently excite and collect light from exciton species with different orientations.

References

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