Revealing the Excitonic Landscape in Mithrene – Hybrid Organic-Inorganic Two-Dimensional Semiconductor

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Metal-chalcogenolate materials are a class of two-dimensional (2D) hybrid semiconducting materials, emerging as an interesting alternative for many optoelectronic applications. Among them, a prototypical representative is the compound AgSePh ("mithrene"), consisting of silver and selenium atoms and organic ligands organised in a two-dimensional structure. Due to both quantum and dielectric confinement the excitonic effects in this system are greatly enhanced, making mithrene a convenient framework to study the exciton physics and an attractive blue light emitter. Owing to the anisotropy of its 2D structure, mithrene displays strongly polarised light absorption and emission, giving way to even more potential applications.

We performed the polarisation-resolved microphotoluminescence and reflectance measurements at low temperatures (T = 5K) to probe the differently polarised excitonic states. In the reflectance spectra we have identified three previously reported excitonic bands [1], named X_1, X_2 and X_3, each of them displaying a linearly polarised substructure. Also, photoluminescence (PL) spectrum originating from the X_1 exciton recombination consists of multiple narrow lines preserving linear polarisation. Interestingly, the intensity of PL emission can be controlled by the polarisation of the exciting light. Regardless of the excitation wavelength, the intensity ratio of one of two components X_{1X} and X_{1Y} can be enhanced or decreased by the rotation of the polarisation angle. This raise questions about the nature of the relaxation processes occurring in mithrene. Our results shed light onto the complex exciton manifold present in AgSePh, which can be useful for light polarisation-sensitive optoelectronics.

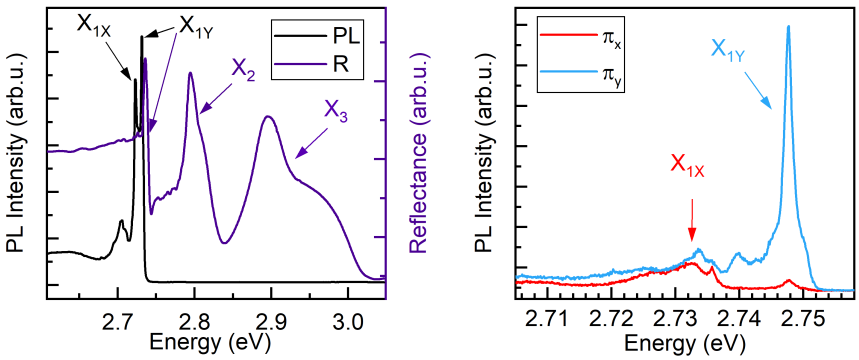

Figure 1: Left: Photoluminescence (PL) and reflectance spectra from AgSePh single crystal. Right: PL spectra obtained with the two orthogonal polarisations of the excitation laser.

[1] Lee, Woo Seok, et al. ACS nano 16.12 (2022): 20318-20328.