Transition metal dichalcogenide alloys as a new class of materials

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Monolayers (MLs) of semiconducting transition metal dichalcogenides (S-TMDs), *e.g.* $MoSe_2$ and WSe_2, are direct bandgap semiconductors characterized by very interesting optical and electronic properties. Alloys of S-TMDs have emerged as materials with tunable electronic structures and valley polarizations [1]. It is therefore crucial to uncover their basic optical properties.

To this end we investigate the low-temperature magneto-photoluminescence (PL) of $Mo_{0.5}W_{0.5}Se_2$ ML embedded in hexagonal boron nitride (hBN) flakes. Measurements were done in magnetic field up to 30 T applied in two configurations: out-of-plane and in-plane. The $MoWSe_2$ ML should combine the properties of both *"parents"*, which are members of different ML families. The WSe_2 MLs belong to the so-called *"darkish"* MLs, in which the excitonic ground state is optically inactive (dark), while the $MoSe_2$ MLs is a representative of *"bright"* MLs with optically active ground state [2]. Fig. 1(a) shows the low-temperature PL spectra at selected out-of-plane magnetic field. The zero-field spectrum is composed of two well resolved emission lines, denoted as X and T, which we attribute correspondingly to the neutral and charged excitons. Upon application of the out-of-plane magnetic field, these transitions split into two circularly polarized components ($\sigma^{\pm}$) due to the excitonic Zeeman effect. The extracted transition energies are presented in Fig. 1(b) along with the extracted effective Lande *g*-factors. It is seen that the *g*-factors for both transitions significantly differ. While the g-factor of the T line of about -4.7 is similar to the reported value of about -4 [3], the g-factor of the X line is much bigger and equal to -7.3. Using DFT calculations, we predict that this value can be understood in terms of particular arrangements of bands in the investigated $Mo_{0.5}W_{0.5}Se_2$ ML. Moreover, the application of the in-plane magnetic field to the ML reveals an additional line observed in magnetic fields above 25 T. This transition is apparent around 16 meV below the X line.

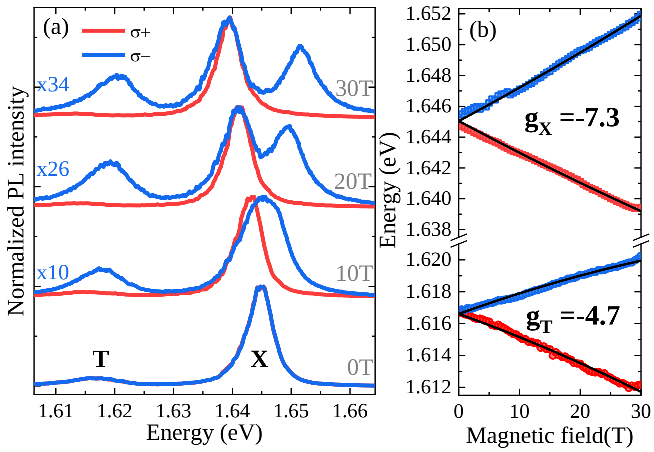

Figure 1 (a) Helicity-resolved PL spectra of $Mo_{0.5}W_{0.5}Se_2$ ML at selected out-of-plane magnetic fields. (b) Extracted transition energies of the X and T lines from panel (a).

We show how our results support the conclusion that the $Mo_{0.5}W_{0.5}Se_2$ ML is a "darkish" material with bright-dark exciton splitting very similar to that of the MoS_2 ML [4].

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