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Effects of surface acoustic waves in the photoluminescence of WSe_2 monolayers

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Abstract

Surface acoustic waves (SAWs) have been employed as an effective tool to manipulate quasiparticle dynamics in semiconductor nanostructures. The dynamic strain and piezoelectric potential modulation carried by the wave strongly interact with optically generated electron-hole pairs, changing the strength of their Coulomb interaction and eventually transporting these quasiparticles along well-defined directions. In this contribution, we investigate the exciton and spin dynamics in WSe_2 monolayers (ML) placed on $LiNbO_3$ substrates under the influence a SAW. We show that the SAW strongly quenches the photoluminescence (PL) emission of the MLs at low temperatures, which is associated to an efficient exciton dissociation process induced by the propagating piezoelectric field. The quenching dynamics is slow, as observed in $MoSe_2$ and MoS_2 MLs [1]. The quenching degree, however, is larger for lower energy emissions in comparison to higher energy ones, as observed in the upper viewgraph of Figure 1. The SAW also affects the spin polarization degree. For lower energy emissions, the spin polarization is insensitive to the SAW. For higher energy emissions the SAW considerably decreases the spin polarization degree (lower viewgraph in Figure 1), indicating an enhancement in the strength of the spin scattering mechanisms induced by the wave. At room temperature, PL quenching dynamics in induced by the SAW is much faster and the degree of PL quenching can be suppressed using high laser excitation powers. Such a decrease of the SAW effect on the carrier dynamics is possibly associated to an effective screening of the SAW piezoelectric potential induced by the photogenerated carrier density.

References

[1] D. Scolfaro, M. Finamor, L. Trinchão, B. L. T. Rosa, A. Chaves, P. V. Santos, F. Iikawa, O. D. D. Couto Jr., ACS Nano, **15**, 15371 – 15380, (2021).

Figures

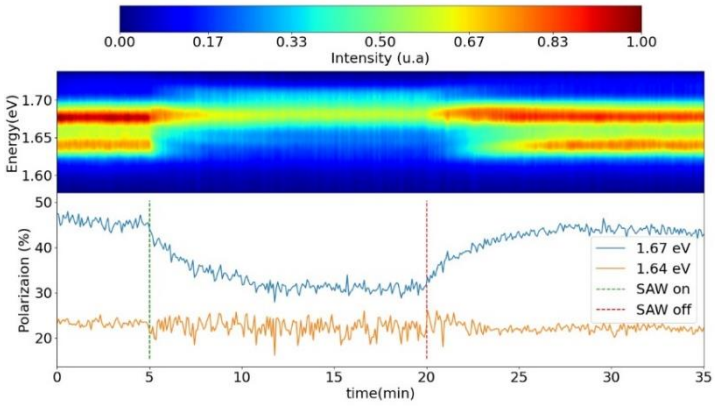

Figure 1: μPL spectrum of a WSe_2 monolayer at 5 K as a function of time (upper viewgraph). Spin polarization as function of time for the 1.67 and 1.64 eV emissions (lower viewgraph). Vertical

dashed lines indicate when the SAW is turned on and off.