Optical properties of transition metal dichalcogenides on GaAs

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Transition metal dichalcogenides (TMDs) are crystalline structures of the form MX$_2$, where M is a transition metal, like Mo or W, and X is a chalcogenide, as S or Se. They are multilayer structures, with X-M-X covalent bonds within a layer and Van der Waals bonds at the interlayer interfaces. As the thickness is reduced from several layers to a single monolayer, a transition is observed from a semiconductor with indirect band gap to a direct band gap in the visible or near infrared frequencies. Therefore, the TMDs are good candidates for the implementation of ultra-thin optoelectronic devices. For this reason, and also for their interest in the study of new physical phenomena, they have been extensively investigated over the last decade. It is already well established that the optical properties of monolayer TMDs are strongly affected by the substrate. In this work, we will present how the optical properties of three different TMDs, MoS$_2$, WS$_2$ and WSe$_2$, are modified by placing them on GaAs substrates. We investigate samples on three types of substrates: p-doped GaAs, n-doped GaAs and semi-insulating GaAs. The monolayers were obtained by mechanical exfoliation and transferred to the substrates. Since the refraction indexes of GaAs and the TMDs are similar, we had to establish a procedure to locate and deal with suitable monolayers. We present a spectral analysis of the luminescence emission for each case, as well as their Raman spectra. We find that the GaAs substrates produce an enhancement in the luminescence of the TMDs. The possible reasons for this behavior will be discussed. We conclude that GaAs/TMDs heterojunctions have a great potential for applications as photodetectors and solar cells.

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