Strong electron-hole asymmetry of the electron-phonon coupling of highly doped transition metal dichalcogenides

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Electron-Phonon interactions affect fundamental physical properties of metals and semiconductors like e.g. their electrical or heat conduction mechanisms. In semiconductors these interactions manifest often in the presence of doping and they can intrinsically limit the functionality of electronic devices. In this paper we probe the electron-phonon coupling in ionic liquid gated mono- and bilayer MoS_2, WS_2, and WSe_2 field-effect transistors with help of Raman spectroscopy. The charge carrier densities, of the order of 10^{14} cm^{-2}, achieved in this type of devices allow us to reveal the existence of a large electron-hole asymmetry in the shift of the Raman active modes as function of the strength and type of the electrostatic doping in the investigated samples. Moreover we identify this effect to be a systematic behavior common to atomically thin group VI transition metal dichalcogenides. With support of ab-initio calculations we determine the strength of the electron-phonon coupling in different points of the Brillouin zone. Hence, we calculate the phonon dispersion over a large range of doping and discuss the relevance of different assumptions which can be chosen to perform the theoretical calculations. These results provide a deep understanding of the electron-phonon interaction of a complete family of materials, i.e. semiconducting group VI transition metal dichalcogenides and might help understanding the superconducting pairing mechanism behind the high carrier density induced superconductivity in this class of materials.