Interfacial Thermal Conductance between Monolayer WSe_2 and SiO_2 under Consideration of Radiative Electron-hole Recombination

Nicholas Hunter [C, S] and Xinwei Wang
Department of Mechanical Engineering, Iowa State University, Ames, Iowa, U.S.A.
hunterni@iastate.edu

This work reports the interfacial thermal conductance (G) and radiative recombination efficiency (β) – also known as photoluminescence quantum yield (PL QY) – of monolayer WSe_2 flakes supported by fused silica substrate via energy transport state-resolved Raman (ET-Raman). A novel laser-assisted synthesis technique was used to produce high quality monolayer samples with low-level defect density relative to other thin film synthesis methods. This is the first known work to consider the effect of radiative electron-hole recombination on the thermal transport characteristics of single layer transition metal dichalcogenides (TMDs). ET-Raman uses a continuous wave laser for steady state heating as well as nanosecond and picosecond lasers for transient energy transport to simultaneously heat the monolayer flakes and extract the Raman signal. The three lasers induce distinct heating phenomena that distinguish the interfacial thermal conductance and radiative recombination efficiency which can then be determined in tandem with 3D numerical modeling of the temperature rise from respective laser irradiation. For the five samples measured, G is found to range from to MW m^{-2} K^{-1} and β ranges from to %. These values support the claim that interfacial phenomena such as surface roughness and 2D material-substrate bonding strength play critical roles in interfacial thermal transport and electron-hole recombination mechanisms in TMD monolayers. It is also determined that low-level defect density enhances the radiative recombination efficiency of single layer WSe_2.