Conjugated Hot Carrier and Phonon Transport in 2D Atomic Layer Materials

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In photon-excitation based thermal characterization of 2D atomic layer materials, hot electrons (hot carrier) are generated and will diffuse out of the heating region, and recombine with holes. This process could significantly affect the phonon transport under probing. Recently, we have developed a novel energy transport state resolved Raman (ET-Raman) method to characterize the conjugated hot carrier and phonon transport by designing different energy transport states in space and time domains (down to picosecond). In ET-Raman, by constructing two steady heat conduction states with different laser heating sizes, we differentiate the effect of R and the hot carrier diffusion coefficient (D). By constructing an extreme state of zero/negligible heat conduction using a picosecond laser, we differentiate the effect of R and material's specific heat. One of the greatest features of ET-Raman is that we can precisely determine R and D without the need of laser absorption and temperature rise of the 2D atomic layer. These two parameters introduce very large and unknown uncertainties and data deviation in measurements reported in the literature. MoS₂ samples down to 1.8 nm thickness have been characterized to uncover its virgin hot carrier mobility which has been difficult to measure in the past. The measured interface thermal resistance is successfully explained by the localized interface bonding level, which can be reflected by the Raman intensity study.