Hot Carrier Transfer and Phonon Transport in Suspended nm WS_2 Films

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This work reports the first results on the conjugated hot carrier diffusivity (D) and thermal conductivity (κ) of suspended nm-thick WS_2 structures. A novel nET-Raman technique is developed to distinguish and characterize these two properties by constructing steady and transient states of different laser heating and Raman probing sizes. The nET-Raman uses a nanosecond pulsed laser and a continuous wave laser for exciting Raman signals and heating samples. κ is found to increase from 15.1 to 38.8 $W \cdot m^{-1} \cdot K^{-1}$ when the sample's thickness increases from 13 to 107 nm. This increase is attributed to the decreased effect of surface phonon scattering in thicker samples. Also, hot carrier diffusion length (Δr_{HC}) for these samples are measured without knowledge of hot carrier's lifetime (τ). Measured D of these four samples are in close range (except the thickest sample). This is due to the fact that lattice scattering for all these samples is similar and there is no substrate effect on our suspended films. nET-Raman is very robust and has negligible effect from laser absorption depth, sample thickness, and laser spot drift during measurement.