Picosecond energy transfer in a transition metal dichalcogenide-graphene heterostructure revealed by transient Raman spectroscopy

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Van der Waals heterostructures composed by graphene (Gr) and monolayer transition metal dichalcogenides (TMD) is promising building blocks for tunneling transistors and flexible electronics. The performance of such devices is critically ruled by interlayer interactions which are still poorly understood in many aspects. Specifically, two classes of coupling mechanisms have been proposed, charge transfer (CT) and energy transfer (ET), but their relative efficiency and the underlying physics are open questions [1]. Here, building on a time-resolved Raman scattering experiment, we determine the electronic temperature profile of Gr in response to TMD photoexcitation, tracking the picosecond dynamics of the G and 2D Raman bands. Compelling evidence for a dominant role of the ET process accomplished within a characteristic time of ~ 4 ps is provided [2]. Our results suggest the existence of an intermediate process between the observed picosecond ET and the generation of a net charge underlying the slower electric signals detected in optoelectronic applications.

References

[1] G. Froehlicher, E. Lorchat, S. Berciaud, Phys. Rev. X, 8 (2018), 011007
[2] C. Ferrante et al., PNAS, 119.15 (2022), e2119726119

Figures

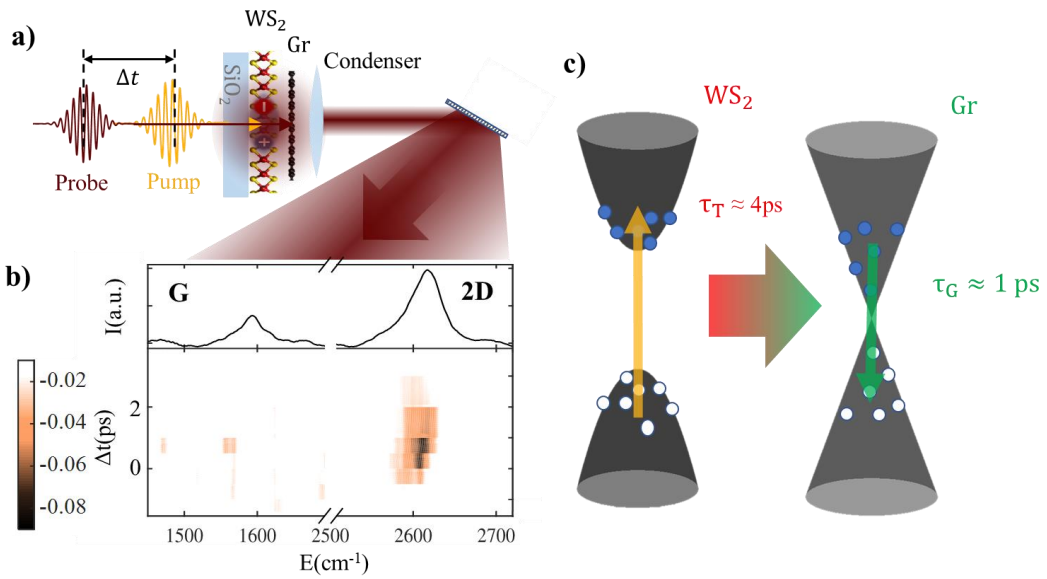

Figure 1: a) Time-delayed pump and probe beams are focused onto a diffraction-limited WS_2-Gr spot and the Raman signal is collected in transmission. b) Pump-off normalized Raman spectra of the G and 2D modes for WS_2–Gr (top) and transient differential Raman spectra in color maps (bottom). c) Sketch of the ET mechanism observed. The pump pulse generates an exciton population in WS_2 (orange arrow). The energy transfer moves the e-h pairs (represented as blue and white circles, respectively) in Gr with a timescale τ_T. Finally, The e-h pairs decay in Gr with a timescale τ_G.