Ultra-long carrier lifetime in neutral graphene-hBN heterostructures under mid-infrared illumination

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Graphene/hBN heterostructures are attractive for advanced THz optoelectronic devices. The recombination dynamics of non-equilibrium carriers in graphene, which rely on carrier–carrier and carrier-optical phonon scattering, have shown to possess sub-picosecond characteristic times at high energy [1]. An additional channel has been recently demonstrated in graphene/hBN heterostructures by emission of 0.2eV hBN hyperbolic phonon polaritons (HPhPs) with <2 ps decay time [2,3]. However, for the development of THz lasers and photoconductive detectors, carrier lifetimes of a few tens of picoseconds are needed.

Using mid-infrared photoconductivity we investigate carrier recombination processes for non-equilibrium carriers below HPhP energy in neutral graphene/hBN Zener-Klein transistors. We report on carrier lifetimes in excess of 30 ps, ultimately limited by interband Auger processes. We unveil the possibility to switch on at finite dc bias or optical power the very efficient electron-HPhP recombination channel. This provides a control of carrier lifetime which falls below few picoseconds upon ignition of HPhP relaxation [4] (Figure 1). Furthermore, we investigate the interplay between optical and electrical pumping and demonstrate their equivalence in suppressing relaxation time at high Joule and/or optical powers.

References

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Figures

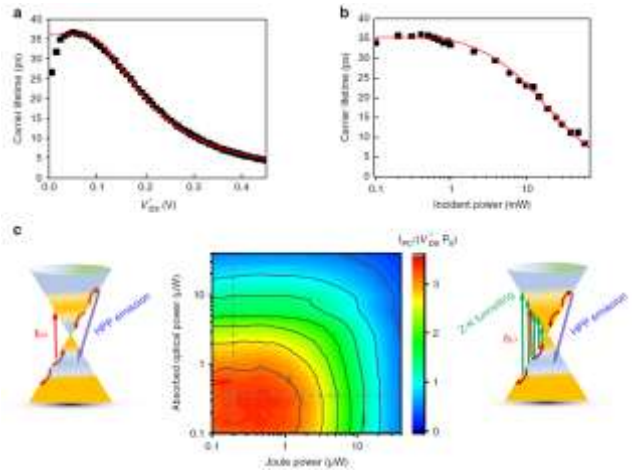

Figure 1: Carrier lifetime as a function of bias (a) and optical power (b). Contour plot of the ratio of the photo response (c) highlighting the equivalence of optical and electrical pumping power in suppressing the long carrier lifetime.