

Electrically Tunable Carrier Lifetime in Gated Bilayer Graphene

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The lifetime of photoexcited carriers is a key parameter that is relevant for the performance of many optoelectronic devices. In particular, it sets the time scale of photocurrent dynamics and therefore influences the response speed of devices such as ultrafast photodetectors, terahertz photoconductive emitters, and other carrier-based photonic systems [1,2]. Bilayer graphene provides a unique platform to investigate and control these dynamics: Unlike conventional semiconductors with fixed bandgaps, a perpendicular electric displacement field breaks the layer symmetry in bilayer graphene and opens a continuously tunable bandgap [3]. This electrostatic control of the band structure offers a powerful route to manipulate carrier recombination processes. However, how the tunable bandgap influences photocarrier lifetime and recombination dynamics remains unexplored.

In this work, we use time-resolved photovoltage measurements on dual-gated hBN-encapsulated bilayer graphene to directly probe the photocarrier lifetime. By tuning the displacement-field-induced bandgap, we achieve electrical control of the lifetime over more than an order of magnitude, ranging from below 50 ps to above 2 ns. Remarkably, the lifetime exhibits a non-monotonic dependence on the bandgap where we identify two distinct recombination regimes. At small bandgaps of less than 5 meV, the carrier lifetime increases with gap energy, whereas at larger bandgaps it decreases with gap energy [4]. These results enable gap-tunable bilayer graphene as a powerful platform for engineering carrier recombination dynamics with immense potential in device applications.

References

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