Electro-optic free-space ultrafast pulse-shaping in a graphene-loaded Bragg resonator

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Efficient ultrafast picosecond laser pulse-shaping in the near-IR, using saturable absorbers, is important for a variety of applications, from optical communications to signal processing. Graphene is an effective tunable absorber at high optical intensities, having the melting point at more than 4000 K and displaying wide-band operation, ranging from visible to THz [1-5]. In our analytical study we combine monolayer graphene with a single-port Bragg nanocavity, designed at λ=1550 nm, which operates in the reflection mode and shows 100% absorption at 300 K [6]. The free-space optical nanodevice is illuminated with high peak power pulses that manage to significantly increase graphene electronic and lattice temperatures. Under high incident power, intrinsic graphene absorptivity reduces, due to Pauli blocking effect, but results into a reflection increase, due to deviation from critical coupling. In our modelling scheme we explicitly study the formation of a hot electron gas in graphene, the phonon-mediated cooling, and the lattice temperatures. Manipulating graphene absorptivity through the appropriate combination of temperature, incident power and doping level, optical modulation is possible. Remarkably, the deviation of temperature- and doping- dependent graphene absorptivity from its critical value modulates the input pulse amplitude, duration and shape, resulting in single, double or even triple peaks.

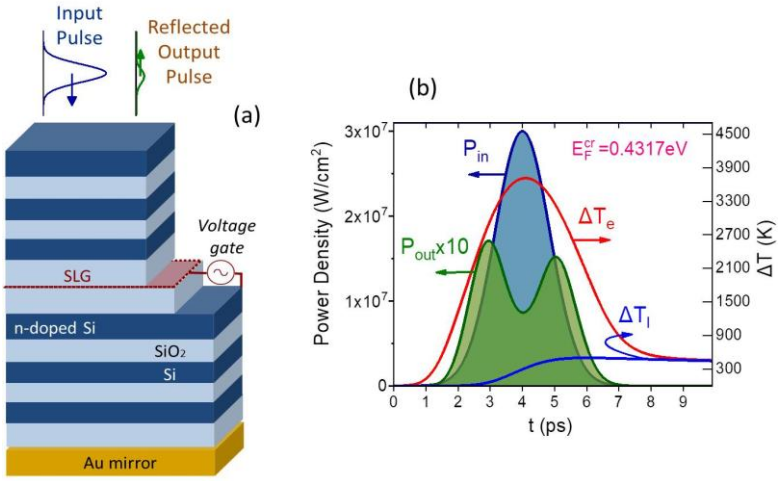

Figure 1: (a) Schematics of a single port asymmetric Bragg nano-cavity with a metal mirror on the backside for pulse-shaping. (b) Gaussian input (P_{in})/output (P_{out}) pulses with the respective electron (ΔT_e) and lattice (ΔT_l) temperature changes (from room temperature) as a function of time, for critical (~300 K) graphene doping.

References

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