Electrically tunable terahertz magneto-absorption and Faraday rotation in graphene

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Abstract

Recent publications have revealed a great potential of graphene for photonic applications, due to a possibility of efficient control of its optical properties by electrostatic gating and plasmonic patterning. Interestingly, the optical absorption of graphene is also highly sensitive to the magnetic field, owing to the extremely small cyclotron mass of charge carriers. Moreover, the magnetically broken time reversal symmetry results in a giant Faraday rotation [1] opening avenues towards realization of graphene-based non-reciprocal devices, such as Faraday rotators and isolators, which would be fundamentally impossible in zero field.

As a first step towards applications, we studied systematically the effect of the key graphene electrical characteristics, namely the carrier concentration and mobility, on its magneto-optical properties, by using a large number of CVD graphene samples. Furthermore, we measured terahertz magneto-absorption and Faraday rotation in large-area CVD graphene field effect transistors, where we combined the magnetic biasing (up to 7 T) with electrostatic gating and plasmonic antidot patterning [2] in order to exploit a complete set of tuning parameters in a same device. This allowed us to achieve a rather deep (up to 50%) magneto- and electro-modulation of graphene properties in a broad range of frequencies. Most significantly, we demonstrate the sign inversion of the Faraday rotation in ambipolar graphene transistors by using the electric field rather than the magnetic field as it is done conventionally. Last but not least, the patterning gives rise to strong magnetoplasmonic modes, which can be used to enhance magneto-optical effects at desired frequencies. Overall, our results show a feasibility of fast-tunable graphene-based terahertz magneto-optical modulators and non-reciprocal devices.

References
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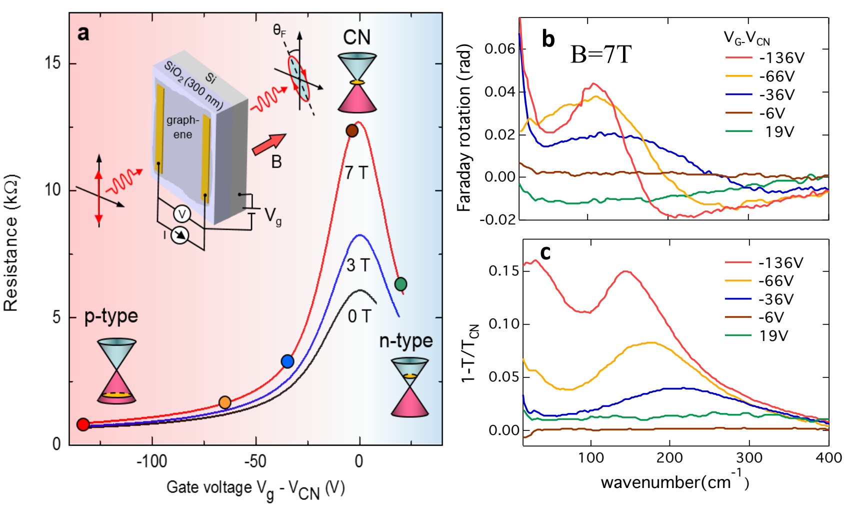
[2] P. Q. Liu F. Valmorra, C. Maissen and J. Faist. Submitted to Optica.

Figures



(**a**) Gate-voltage dependent magneto-resistance of a 3x3 mm^2 ambipolar CVD-graphene transistor with an antidot patterning. The inset shows schematically the device and the magneto-optical experiment. The Faraday rotation (**b**) and absorption (**c**) at 7 T at selected gate voltages, indicated by circles in (a).