Hybrid graphene–quantum dot phototransistors with ultrahigh gain

Ivan Nikitskiy, Louis Gaudreau, Michela Badioli, Johann Osmond, Maria Bernechea, F. Pelayo Garcia de Arquer, Fabio Gatti, Gerasimos Konstantatos and Frank H. L. Koppens

ICFO – The Institute of Photonic Sciences, Av. Carl Friedrich Gauss 3, 08860 Castelldefels (Barcelona), Spain
ivan.nikitskiy@icfo.es

Abstract

Graphene is an attractive material for optoelectronics and photodetection applications because it offers a broad spectral bandwidth and fast response times. However, weak light absorption and the absence of a gain mechanism that can generate multiple charge carriers from one incident photon have limited the responsivity of graphene -based photodetectors. We have developed a novel hybrid graphene–quantum dot phototransistor that exhibits ultrahigh photodetection gain and high quantum efficiency, enabling high-sensitivity and gate-tunable photodetection.[1] The key functionality of this light-activated transistor is provided by a layer of strongly light-absorbing and spectrally tunable colloidal quantum dots, from which photogenerated charges can transfer to graphene, while oppositely charged carriers remain trapped in the quantum-dot layer. The main feature of the device is its ultrahigh gain, which originates from the high carrier mobility of the graphene and the recirculation of charge carriers during the lifetime of the carriers that remain trapped in the PbS quantum dots. The unique electronic properties of graphene offer a gate-tunable carrier density and polarity that enable us to tune the sensitivity and operating speed of the detector. We exploit this to maximize the photoconductive gain or to fully reduce it to zero, which is useful for pixelated imaging applications, where the implementation of nanoscale local gates enables a locally tunable photoresponse.

References

[1] Gerasimos Konstantatos, Michela Badioli, Louis Gaudreau, Johann Osmond, Maria Bernechea, F. Pelayo Garcia de Arquer, Fabio Gatti and Frank H. L. Koppens, Nature Nanotechnology, 7 (2012) 363–368.