Graphene nano-optoelectronics for capturing and manipulating light at the nanoscale

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Graphene, a two-dimensional sheet of carbon atoms, has recently emerged as a novel material with unique electrical and optical properties, with great potential for opto-electronic applications, such as ultrafast photo-detection and optical switches. In this talk, I will review recent experimental work on exploiting graphene as a host for guiding, switching and manipulating light and electrons at the nanoscale [1,2]. This is achieved by exploiting surface plasmons: surface waves coupled to the charge carrier excitations of the conducting sheet. Due to the unique characteristics of graphene, light can be squeezed into extremely small volumes and thus facilitate strongly enhanced light-matter interactions. I will discuss recent observations of propagating and localized optical plasmons in graphene nano-structures. The plasmon wavelength can be tuned and plasmon propagation can even be switched on and off in-situ, simply by tuning the carrier density by electrostatic gates. These results pave the way towards ultrafast modulation of nanoscale optical fields, resonantly confined in graphene nano-structures or propagating along graphene ribbons.

The second part of the talk is devoted to a novel hybrid graphene-quantum dot photodetector [3] which exhibits a gain mechanism that can generate multiple charge carriers from one incident photon. Strong and tunable light absorption in the quantum-dot layer creates electric charges that are transferred to the graphene, where they recirculate many times due to graphene's high charge mobility and long trapped-charge lifetimes in the quantum-dot layer. We demonstrate a gain of 10^8 electrons per photon and a record-high responsivity of 10^7 A/W. Our devices also benefits from gate-tunable sensitivity and speed, spectral selectivity from the short-wavelength infrared to the visible, and compatibility with current circuit technologies.

References

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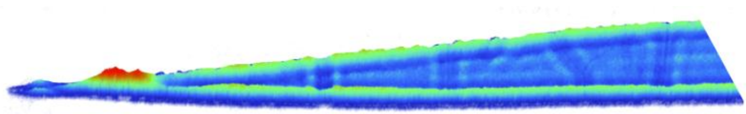

Figure 1

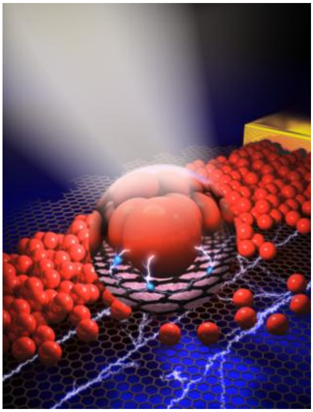

Figure 2