Mid and long-wave infrared photocurrent spectroscopy by electrical detection of 2D polaritons

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Abstract:

Spectral selectivity for mid and long-wave infrared detection is at the heart of a myriad of applications such as molecular spectroscopy, thermal imaging, etc. Polaritons (plasmons, phonon polaritons) in 2D materials have been widely explored in the last years due to its intriguing optoelectronic properties [1,2]. However, its employment for efficient photodetection in the mid-IR and LWIR range at room temperature has remained elusive, which typically an external detector (e.g. MCT) is required to probe them.

In this work, we combine in one single platform the efficiently excited polaritonic material that also acts as a detector itself. [3] This approach prevents the need of using an external detector. We fabricate several devices based on high quality graphene encapsulated by hexagonal boron nitride (hBN) on top of metallic rod arrays that serve to launch the hBN phonon polaritons and/or graphene plasmons. We also doped graphene via an electrostatic potential applied between these rods and graphene separated by a thin hBN layer. By following this approach we reach high Fermi level values of the order of 0.4 eV.

We initially perform transmission measurements using FTIR. We observe graphene plasmons and the hybridize plasmon phonon polaritons that show a blueshift when increasing the gate voltage (Fermi level). This confirms the plasmonic behaviour of these polaritons. Moreover, we observe a narrow linewidth of these resonances that show an extinction value above 10%. Additionally, these metallic gratings form two independent gates to create a graphene pn-junction. We characterize the photoresponse that we determine the photothermoelectric effect as the dominant mechanism. We perform photocurrent spectra in the mid and long-wave infrared range (from λ = 6.6 to 13.6 µm) at different gate voltages for tuning the graphene Fermi level. We identify peaks in the spectrum that evolves and blueshift by increasing the gate voltage. In particular, we observe hybridized plasmon phonon polaritons at the upper and lower reststrhalen bands of hBN. Also we observe acoustic graphene plasmons that are confined between the metal and separated by 2-6 nm of hBN. We vary the grating period and substrate (SiO2 or CaF2) to shift the spectral position of the resonances. We also we investigate the influence of using isotopically enriched hBN (B10). Our results show excellent agreement with the simulations and semianalytical model.

To summarize, we show mid and long-wave infrared photocurrent spectroscopy via electrical detection of acoustic graphene plasmons, hyperbolic phonon-polaritons and its hybridized modes. This approach enables a suitable platform for spectrally selective detection in this range and has the potential to constitute high accuracy thermal imaging, compact spectrometers, etc.

References

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