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Spectrometer free molecular sensing with graphene plasmons

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Abstract: Graphene plasmons have emerged as an attractive alternative to noble metal plasmonics for applications regarding infrared sensing. Both the tunability and the higher quality of graphene plasmons make them ideal for surface-enhanced infrared absorption experiments. With this technique molecular resonances, which are unique for each molecule, can be recorded for a wide range of wavelengths. In this work we study a recently proposed apparatus [1-3] where absorption is integrated over photon energy as a function of graphene doping level. Doing so, one can utilize this method without the use of spectrometers and laser sources in order to resolve the light wavelength. Instead, a molecular resonance corresponds to a certain doping level which in turn can be corresponded to specific photon energy. We investigate, via FDTD simulations, all these factors that can influence the device's spectral resolution, including graphene's short relaxation time in the spectral vicinity of graphene's phonons. By using the plasmon quality factor, which is critical for the method's efficiency, as a figure of merit we conclude that the simple addition of an Au mirror at a certain distance can dramatically enhance the resolution of the device. We also explore the possibility of using graphene's much sharper quadrupolar term, instead of the broader dipolar term which is commonly used, in order to be able to identify molecular resonances that are indistinguishable when a broad plasmon resonance is used.

[1] Marini et al, ACS Photonics 2015
[2] Rodrigo et al, Science 2015
[3] Farmer et al, ACS Photonics 2016