# Acoustic THz graphene plasmons and mid-infrared polaritonic nanoresonators at low temperatures

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Polaritons are coupled excitations of incident light with charged particles (plasmons polaritons) or lattice vibrations (phonon polaritons). In particular, the polaritonic properties of two-dimensional (2D) materials become extreme in several aspects, such as light confinement and long lifetimes. Hence, they lead to a myriad of applications for gas and molecular sensors, enhanced photodetectors and quantum technologies.

In this work, we show an efficient platform to launch acoustic THz graphene plasmons by using an antenna that defines the plasmonic cavity.[1] These plasmons are measured via far field THz photocurrent spectroscopy. We test several devices that show peaks in the photovoltage, which correspond to peaks in absorption due to graphene acoustic plasmons present at the same gate voltage/Fermi level doping. We measure from room temperature down to 5 K, where the resonant peaks vanish at high temperatures, while at low temperatures become prominent. We observe that these resonances are shifted and additional features appear when changing local gate and back gate voltages. The photoresponse and resonant peaks drop significantly when polarizing the incident light perpendicular to the antenna's main axis. Moreover, we measure at different incident frequencies (from 1 to 4 THz) to further tune these resonances The experimental results show good agreement with the numerical calculations and dispersion relation of the acoustic THz graphene plasmons.

Then, we show a novel concept of 2D polaritonic nanoresonators that consist of merging into one single platform the polaritonic material and the detector as shown in Figure 1b.[2,3] We obtain a highly compact device since we get rid of the need for an external detector for performing infrared spectroscopy. We geometrically and electrically tune these nanoresonators to change their spectral photoresponse. Due to this, we can identify different interactions such as the hybridization between graphene plasmons with the HPPs and modification of the HPPs waveguide modes due to the graphene doping. We investigate the photoresponse of these 2D polaritonic nanoresonators as a function of the temperature, reaching values down to 30 K.[3] The devices show higher values of photocurrent due to the interplay of the contributions of the photothermoelectric effect and longer lifetimes of the polaritonic resonators. We determine that the Q factor values increase significantly at these lower temperatures by reaching values up to 300 and the results are supported by theoretical simulations.

References

[1] D. De Fazio*, S. Castilla* et al. In preparation.
[2] S. Castilla, et al. To be submitted.
[3] S. Castilla, et al. In preparation.

Figures

a)

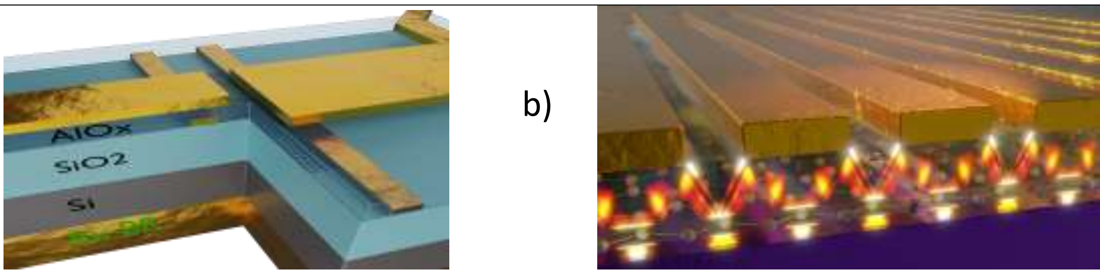


**Figure 1: a)** Cross-section view of the graphene plasmonic THz photodetector. **b)** Schematic of the 2D polaritonic nanoresonator that shows the field intensity of the propagating mode.