THz and Mid-Infrared Plasmonic Excitation in 3D Nanoporous Graphene

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Abstract

We report observation of Infrared plasmonic excitations in three-dimentional Nanoporous graphene, and their tunability under chemical doping, pore-size and temperature. Despite the inherently high disorder of nanoporous structures, experimental Infrared spectra exhibit a clear dependence of plasmon resonance frequency on doping and average pore-size. Finally the temperature dependence of the plasmonic absorption makes this new configuration of graphene appealing for room- and high-temperature applications.

Discussion

The field of graphene plasmonics (2D) holds great promise for applications due to long lived collective oscillations and extreme light confinement [1]. Retrieving a 3D configuration out of a 2D material is interesting for future opto-electronics, chemical sensing and energy applications. Three-dimentional (3D) Nanoporous graphene (NPG) has recently been obtained [2,3] with a new fabrication approach based on chemical vapour deposition (CVD) that allows to construct the 2D graphene into a 3D structure (see Fig. 1a), preserving the unique physical characteristics of graphene [2,3], such as mass-less Dirac fermions with high electron mobility.

We Performed THz and Mid-Infrared optical conductivity measurements with a Michelson Interferometer, on several NPG samples with varying pore-size and chemical doping levels in a wide range of temperatures (T=10-500K). As depicted in fig. 1b, the experimental data exhibit two components: the inter-band transition reaching the universal value (σ_0=6.08 10^{-5} S cm^{-1}) at high frequency and a low-energy peak, with no evident Drude behavior, which we identify with a plasmonic absorption peak.

The conductivity model implemented takes into account a spatial distribution of Fermi Energies within the Infrared spot-size, which is expected for such an inhomogeneous sample, while the plasmonic absorption is modeled with a Lorenzian line-shape. This model simultaneously retrieves the plasmonic parameters and an average Fermi energy, which allows to discuss their correlation.

As a function of temperature the plasmonic absorption feature exhibits a strong dependence, its intensity increasing almost linearly with T, which is particularly interesting for room-temperature and solar-energy applications.

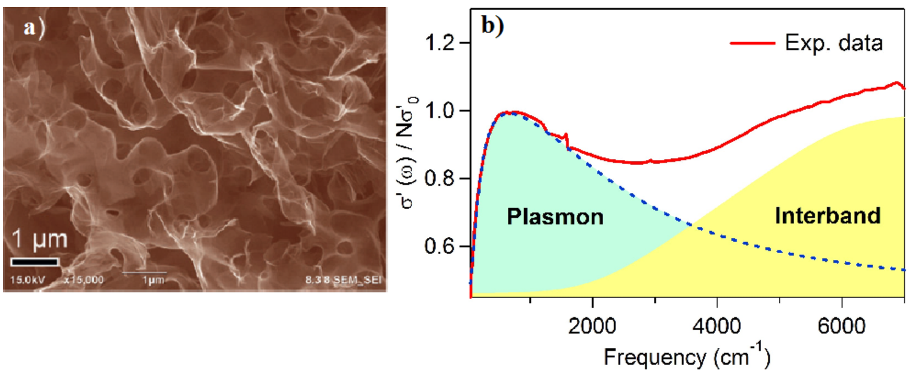

Fig. 1 a) SEM image of Nanoporous Graphene with average pore size of 200 nm. b) Optical conductivity measurement (solid red) of Nitrogen-doped NPG which exhibits the transition to the universal value (yellow shade) above the chemical potential, while a strong plasmonic peak (dotted blue) due to the localized oscillation of carriers in the nano-pores.

References

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