Highly confined low-loss plasmons in graphene-boron nitride heterostructures

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Graphene plasmonics is an excellent platform for strong optical field confinement with relatively low damping. This enables new device classes for deep subwavelength metamaterials [1,2], single-photon nonlinearities [3], extraordinarily strong light-matter interactions [4] and nano-optoelectronic switches.

The problem was that thus far strong plasmon damping was observed [5-7], with both impurity scattering [8] and many-body effects in graphene [5] proposed as possible explanations. This strong damping hindered the further development of graphene plasmonic devices.

Using van der Waals heterostructures [9] new methods to integrate graphene with other atomically flat materials have become available. Especially graphene encapsulated between two films of hexagonal boron nitride (h-BN) shows extremely high room temperature transport mobility of charge carriers which is only limited by the scattering with acoustic phonons in the graphene [10].

We show results were we exploit near-field microscopy to image propagating plasmons in high quality graphene encapsulated between h-BN [11]. Frequency dispersion and particularly plasmon damping in real space is determined and we show that these high quality graphene samples show unprecedented low plasmon damping combined with extremely strong field confinement. We identify that the main damping channels are intrinsic thermal phonons in the graphene [12] as well as dielectric losses in the h-BN [13]. These results are the key for the development of graphene nano-photonic and nano-optoelectronic devices.

References

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