# Light matter interaction graphene/h-BN and graphene/h-BN/graphene heterostructures mediated by surface acoustic waves

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Surface plasmon polaritons (SPPs) in graphene– hybrid excitations of Dirac quasiparticles and photons – have emerged as an outstanding platform for exploring light-matter interaction at the nano-scale. These SPPs couple strongly to surface optical (SO) phonons in the substrate leading to hybridized surface plasmon-phonon polaritons (SPPPs). Moreover, unlike conventional SPPs in metals, graphene SPPPs can be tuned in situ through the modulation of the carrier density by electrostatic gating, covering the mid-IR to THz range. Owing to their extremely short wavelengths, however, to experimentally excite them, a large mismatch in momentum needs to be overcome by a photon to couple with a plasmon into a SPP. Here we demonstrate that a surface acoustic wave (SAW) can be used to generate propagating SPPPs in graphene/h-BN and graphene/h-BN/graphene heterostructures on piezoelectric substrates over a broad energy range (fig 1a and 1b). The h-BN between the graphene and the piezoelectric substrate not only significantly changes the SPPP dispersion but also enhances the lifetime as compared to the previously studied graphene/piezoelectric system [1]. The SPP dispersion of graphene splits into multiple branches due to the coupling with the SO phonons of both h-BN and piezoelectric substrate [2]. In addition, hyperbolic phonon branches appear in the case of multilayer h-BN which then also couple to graphene plasmon and leads to hyperbolic plasmon-phonon polaritons (HPPPs). Moreover, the addition of a second graphene layer is shown to further disperse and strengthen the SPPPs (see fig. 1(c). Also, in case double layer graphene additional modes, acoustic modes, will appear (as shown in fig. 1(b) because of interlayer carrier-carrier interaction which further increases the magnitude to correlation energy and decreases the quasiparticle velocities (~c/300) and highly confined closed to particle-hole continuum.

## References

[1] J. Schiefele, J. Pedros, F. Sols, F. Calle and F. Guinea, Phys. Rev. Lett. 111 (2013) 237405
[2] R. Fandan, J.Pedros, J. Schiefele, A. Bosca, J. Martinez and F. Calle, J. Phys. D: Appl. Phys. 51 (2018) 204004.

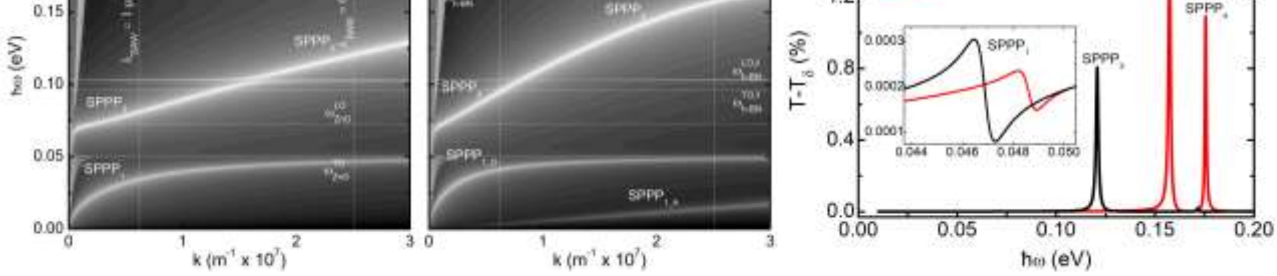

**Figure 1:** SPPPs dispersion in (a) G/h-BN/ZnO and (b) G/h-BN/G/ZnO. (c) Generation of SPPPs by a SAW with wavelength $\lambda_{SAW}$ = 250 nm.