SAWtrain Research Highlight 4:
"Acoustically driven surface and hyperbolic plasmon-phonon polaritons in graphene/h-BN heterostructures on piezoelectric substrates"

Plasmonics is the field of study of the trapping of light at the nanoscale, that leads to an increase in the associated electric field strength resulting in enhanced light-matter interaction. This is promising for various applications such as integrated optics, metamaterials and cloaking, biosensing, and photovoltaics. Hybrid light-matter modes involving collective oscillations of an electron plasma in a conductor with external electromagnetic fields at the surface of matter are called surface plasmon polaritons (SPPs). Graphene is a two-dimensional material hosting an electron plasma with a carrier density that can be tuned by simply applying a gate voltage, thus making its SPPs tuneable in the mid-infrared to THz range. However, a large momentum mismatch needs to be overcome to excite them.

In this work, the authors demonstrate a unique way to excite SPPs in graphene/h-BN heterostructures on a piezoelectric substrate by using surface acoustic waves (SAW) produced by supplying rf-power to an interdigitated transducer (IDT). Graphene is periodically modulated by the SAW, forming a virtual diffraction grating that provides the photons with the extra momentum required to couple into a SPP. h-BN is a two-dimensional insulator without dangling bonds, widely used as an ideal substrate for graphene providing it with very high mobility, which in turn increases the SPP lifetime.

Moreover, h-BN is a natural hyperbolic dielectric, i.e. its dielectric function components have an opposite sign within the reststrahlen bands, where graphene plasmons couple strongly to both surface and hyperbolic (waveguided) phonons in h-BN, leading to hybridized surface and hyperbolic plasmon-phonon polaritons (SPPPs and HPPPs) with lifetimes exceeding 1 ps and deep subwavelength confinement of light up to a factor of 100. In addition, the SPPPs and HPPPs can be tuned by varying the carrier density in graphene and the thickness of the h-BN interlayer.

These results pave the way for engineering SAW-driven graphene/h-BN plasmonic devices and metamaterials covering the mid-IR to THz range.

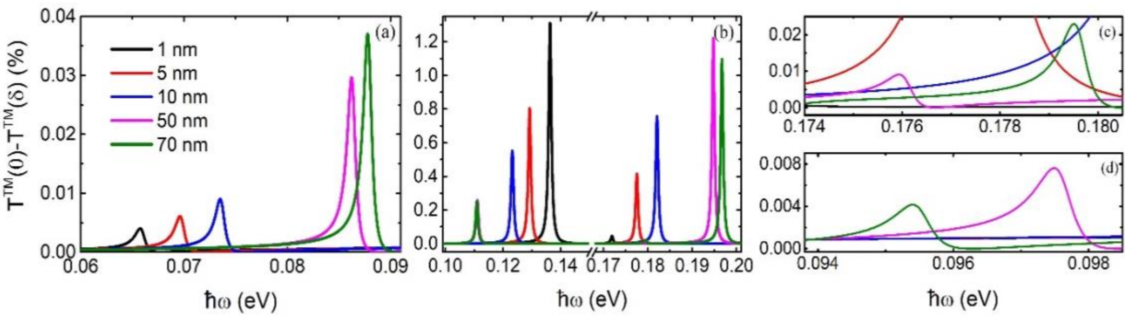

Figure: SAW-driven generation of (a)-(b) SPPPs and (c)-(d) HPPPs in graphene/h-BN/AlN systems with various h-BN film thicknesses, as indicated by the reduction in the transmission of the light when the SAW is launched.

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