Surface acoustic waves in graphene & 2D materials for manipulating light-matter interactions

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Surface acoustic waves (SAWs) are especially well suited for modulating graphene and other 2D materials as their strain and piezoelectric fields are strongly concentrated at the surface of the piezoelectric substrate that supports the 2D crystal. Moreover, many 2D materials are themselves piezoelectric, enhancing the capabilities of strain modulation. The interdigital transducer (IDT) technology permits to excite the SAWs electrically to generate strain locally at very high frequencies, as shown in figure 1. In this talk, we will first demonstrate that this strain allows to modulate dynamically the optical and vibrational properties of graphene, as proven by the change on its Raman signature [1]. Second, we will show that SAWs also provide an outstanding platform for confining light at the nanoscale, exploiting the strengthening of its associated electric field, which results in enhanced light-matter interactions or quasiparticles. Thus, the strain field of the SAW can create a dynamic optical grating allowing to launch propagating polaritons in unpatterned graphene and other 2D materials. In particular, we will present the generation of SAW-driven surface plasmon-phonon polaritons in graphene and graphene/h-BN systems [2, 3], the latter also supporting hyperbolic modes. Finally, we will show how this concept can be generalized to stacks of 2D semiconductor materials (for example MoS_2 and black phosphorus) on thin metal layers, where the SAW generates surface plasmon-exciton polaritons (or plexcitons) [4]. These SAW-mediated architectures pave the way for implementing nanophotonic devices and biosensors, where polaritons can serve as ultrafast and low power signal carriers and ultrasensitive probes, respectively.

References

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Figures

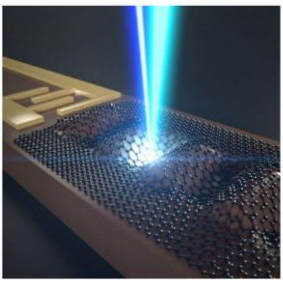

Figure 1: A SAW generated with an IDT deforms the graphene (or other 2D crystal) locally and dynamically to manipulate the properties of the material and/or the light-matter interaction.