Coupling light into graphene plasmons with the help of surface acoustic waves

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Abstract

Surface plasmon polaritons (hereafter plasmons) are essentially light waves trapped to the surface of a conductor due to their interaction with conduction electrons. The strong spatial confinement of the electromagnetic field and its coupling to charge carriers allow for the manipulation of light at subwavelength scales (beyond the diffraction limit of classical optics), opening the possibility to integrate electronics and optics at the nanoscale. Further promising plasmonic applications include, for example, the control of quantum-optics devices, single molecule detection, nanomedicine, metarmaterials, and light harvesting. Recently, the possibility to use graphene for plasmonic devices has received considerable attention [1,2]. In comparison to conventional conductors, graphene offers unique possibilities for tuning its plasmonic properties. However, in the experiments realized so far, graphene plasmon laser coupling required either complex near-field techniques or the patterning of micro- or nanoscale arrays for far-field coupling, where edge scattering reduces the localized plasmon lifetime, hindering the potential of the graphene plasmonic applications. Thus, an efficient method to excite propagating graphene plasmons for the development of integrated and scalable graphene plasmonic devices is still needed.

In order to overcome this problem, we have recently proposed a method to couple far-field radiation into propagating graphene plasmons by periodically deforming a continuous graphene sheet with an electrically generated surface acoustic wave (SAW) [3]. This mechanisms allows to create a tunable optical grating without the need of any patterning, thus eliminating the edge scattering. An interdigital transducer (IDT) on a piezoelectric film is used to launch the SAW across the graphene sheet, as shown in Figure 1. By diffraction at the grating, incident laser light can overcome the momentum mismatch and excite propagating plasmons in the graphene sheet. Independently, another research group arrived at a similar proposal using an external mechanical vibrator [4]. Both works have been highlighted in synopsis articles published in the popular science magazines Physics [5] and Chemistry World [6].

In this contribution, we will briefly review the potential applications of graphene plasmonics and the different methods used so far for the generation of graphene plasmons. We will then present the details of our novel approach that allows to benefit from the simple optics of the far-field coupling technique while permitting to excite propagating plasmons in continuous graphene, otherwise impeded in patterned graphene sheets that only allows localized plasmons affected by edge scattering. Moreover, the use of an integrated transducer to generate the waves enables the fabrication of graphene plasmonic devices by the microelectronics industry. In addition, our approach permits to switch the laser-plasmon coupling electrically via the high-frequency signal at the IDT as well as to take advantage of the IDT technology for developing many different plasmon functionalities. For example, curved IDTs creating interfering SAWs, could easily be used for plasmon focusing.

References

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Figures

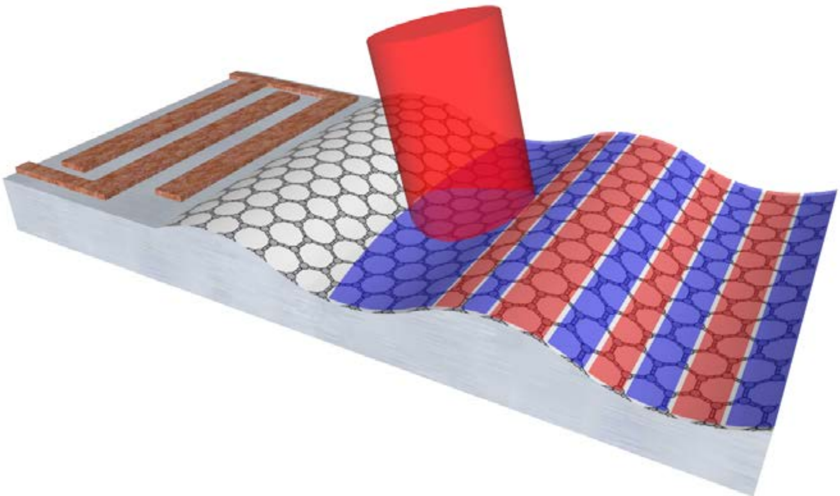

Figure 1: Sketch of the proposed device for coupling laser light into propagating graphene plasmons.