Plasmon propagation enhancement in graphene waveguides via antenna design and nanopatterning

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Abstract

Converting light to Surface Plasmon Polaritons (SPPs) holds the promise of optical circuitry on chip with dimensions much smaller that the free space wavelength. Graphene provides the key advantage that the density of free carriers can be tuned over a large range by external gate electrodes of via doping, which in turn enables controlling of the SPP energy.[1] Towards plasmonic devices the major challenges are the efficient coupling of the light to the plasmons, plasmon propagation and the modulation of the plasmon signal for information processing[2], and finally the readout mechanism.

In this contribution we address the possibilities of noble metal antennas fabricated on graphene layers for light to plasmon coupling, and the possibilities of different antenna designs for efficient and directional plasmon propagation. The design of resonant antenna devices that receive and transmit optical signals coherently, in an amplified and directive way, can represent a powerful tool towards high speed communication devices based on SPPs.[3] We test different antenna designs and waveguide shapes for such coupled systems of graphene waveguides and noble metal antennas using the commercially available software COMSOL®. We discuss the figures of merit of several highly directional and frequency selective antenna designs that are used to enhance the electromagnetic component of the incident radiation, which couples to the graphene plasmons. Furthermore we optimize the shape of the graphene waveguide for improving plasmon propagation length, and we introduce new ideas of micro- and nanostructuring of the waveguide that can dramatically increase the propagation length.

References

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Figures

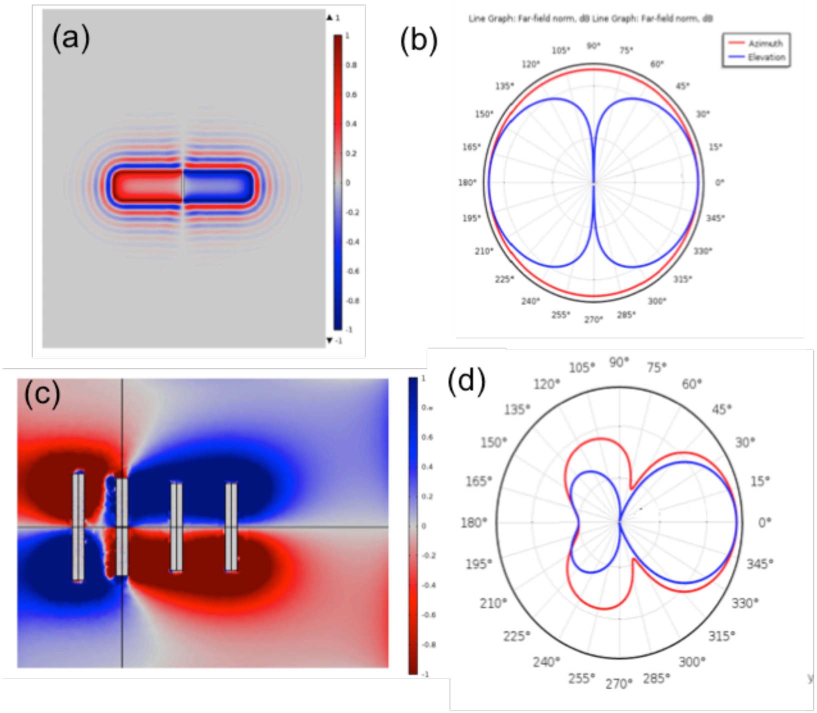

Fig 1. Simulated field enhancement of dipole antennas fabricated on single layer graphene: (a,b) Near- and far-field of a standard dipole antenna; (c,d) Near- and far-field of a Yagi-Uda antenna consisting of a radiator, a reflector, and two directors. (a,c) show the real part of the electric field associated to the plasmon propagation in graphene.