Graphene Plasmonics

P. Avouris

IBM Research Division, T. J. Watson Research Center, Yorktown Heights, NY 10598, USA

I will present an overview of our work on the properties and potential applications of the collective electronic excitations (plasmons) of graphene. First, I will briefly review the single electron excitations in this material from the UV to THz frequencies and their tuning. Then, I will focus on the properties of its plasmon excitations and compare them with those of the surface plasmons of noble metals. I will mostly concentrate on localized graphene plasmons in lithographically patterned nano- and micro-structures (quantum dots and ribbons) [1,2]. The emphasis will be on the optical behavior in the infrared and THz regions of the spectrum, the role of size quantization, electrostatic and chemical doping effects, and the effects of external electric and magnetic fields on the plasmon resonances [3,4,5]. Plasmon-plasmon hybridization and hybridization of graphene plasmons with substrate and adsorbed overlayer optical phonons as well as plasmon damping mechanisms will be analyzed [4,6,7,8]. Applications of graphene plasmons in passive THz optical elements, in the enhancement of photocurrents in graphene infrared photodetectors [9,10], and the enhancement of infrared absorption spectra of molecules will be discussed [11]. Finally, I will consider how by combining graphene plasmons with the polaritons of hyperbolic materials one can achieve new optical functionalities [12].

References

[1] T. Low, P. Avouris, *ACS Nano* 8 (2014).1086.
[2] P. Avouris, F. Xia, *MRS Bulletin* 37 (2012) 1225.
[3] H. Yan et al. *Nature Nano* 7 (2012) 330.
[4] H. Yan et al. *Nature Photon*ics. 7 (2013) 394.
[5] H. Yan, et al., *Nano Letters* 12 (2012) 3766.
[6] H. Yan, et al. *Nano Lett*. 14 (2014) 4581.
[7] T. Low et al. *Phys. Rev. Lett.* 112 (2014) 116801.
[8] D.B. Farmer et al. Nano Lett. 15 (2015) 2582.
[9] M. Freitag et al. *Nature Commun*. 4 (2013) 1951.
[10] M. Freitag et al. *ACS Nano* 8 (2014) 8350.
[11] Y. Li et al. *Nano Lett.* 14 (2014) 1573.
[12] A. Kumar et al. *Nano Lett.* 15 (2015) 3172.

2. M. Freitag, T. Low, F. Xia, Ph. Avouris, Nature Photonics 7, 53 (2013).
3. F. Xia et al., Nature Nano 4, 839 (2009).
4. T. Mueller, F. Xia, Ph. Avouris, Nature Photon. 4, 297 (2010).
5. M. Freitag, et al. Nature Commun. 4, (2013).
6. H. Yan et al. Nature Nano 7, 330 (2012).
7. H. Yan et al. Nature Photon. 7, 394 (2013).