Infrared Spectroscopy of Tunable Magneto-Plasmons in Graphene

Hugen Yan (IBM), Zhiqiang Li (NHMFL), Xuesong Li, Wenjuan Zhu, Phaedon Avouris, and Fengnian Xia (IBM)

Introduction

Due to its linear electronic band structure, the charge carriers in graphene behave as massless Dirac fermions. Graphene plasmons are collective oscillations of these fermions, which possess many fundamentally different properties from that of conventional two-dimensional plasmons involving carriers with non-zero mass. One of the differences is the carrier density dependence of the plasmon resonance frequency. As a result, the study of graphene plasmons emerges as a very dynamic and fast developing research field.

Experimental

We successfully performed far-IR transmission measurement of graphene disk arrays[1], anti-dot arrays and ring arrays[2] under a magnetic field up to 17.5 T using SCM3. In our previous experiments, graphene samples were grown by chemical vapor deposition (CVD) and then transferred to proper substrates. We used electron beam lithography and oxygen plasma etching to define graphene disks. IR transmission spectra were measured using a Fourier transform spectrometer at SCM3 of NHMFL.

Results and Discussion

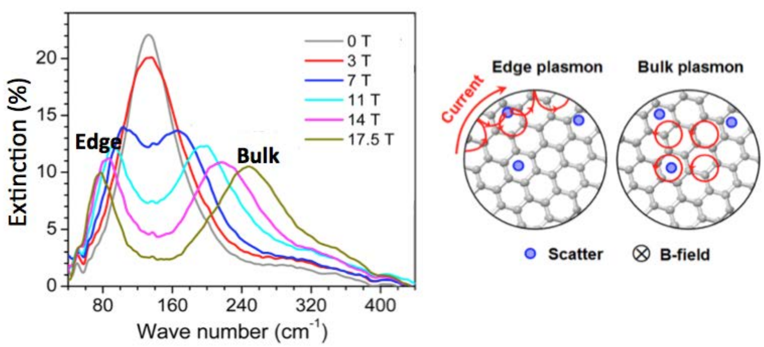

Figure 1: Left panel: Extinction in transmission in graphene plasmonic micro-disks in zero and finite magnetic fields. The edge and bulk magneto-plasmons are indicated. Right panel: Illustration of the charged carrier motion for the edge and bulk modes. Data were taken at SCM3 of NHMFL.

We investigated the optical response of the plasmons in micrometer-sized graphene disks in high magnetic fields up to 17.5 T [1]. Our study shows that the plasmon resonance splits into edge and bulk modes in magnetic fields, as shown in **Figure 1**. Due to the linear band structure of graphene, the splitting exhibits a sensitive doping dependence, which is not observed in conventional two-dimensional electron gas systems [1]. Moreover, the lifetime of the two modes can be dramatically modified by magnetic fields, with the edge plasmons developing increasingly longer lifetimes (narrower linewidth) in high fields. The latter behavior can be understood from the suppression of backscattering at the edges.

Conclusions

Our findings, particularly the control of plasmon lifetime by magnetic fields, may lead to applications in magneto-optical devices, such as optical modulators and Faraday isolators. Moreover, this work opens a new avenue to explore the edge physics of graphene.

Acknowledgements

Part of this work was performed at the National High Magnetic Field Laboratory, which is supported by NSF DMR-0654118, the State of Florida, and DOE.

References

[1] H. Yan *et al*., Nano Lett. 12, 3766 (2012).
[2] H. Yan *et al*., arXiv:1205.6841v1.