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Tailoring Graphene: from optical control of carrier density to bandgap engineering in graphene nanoribbons

Abstract
Owing to their massless nature, charge carriers in graphene possess record mobilities up to 350,000 $cm^2 \cdot V^{-1} \cdot s^{-1}$.[1] The application of graphene for high mobility devices requires switching the conducting states in graphene, so that control of the carrier density or Fermi level is critical. Control of the Fermi level is conventionally achieved by electrostatic or electrochemical gating.[2] Such Fermi energy tuning schemes are effective, but typically require elaborate clean room fabrication, especially when sub-micron local gating structures are required. Here, I will present two examples of effectively modulating the doping structures in graphene in a convenient and reversible manner, by: (1) optically controlling the adsorption-desorption equilibrium of molecular oxygen (a p-dopant) by laser excitation to dynamically modify the doping concentration in graphene;[3] and (2) tuning the photo-induced structural change and charge transfer dynamics between the grafted molecules and graphene.[4] Additionally, we demonstrate that the optical control of Fermi energy in graphene allows one to optically write doping structure with spatial control, opening new opportunities for creating complex doping features in a convenient way.

The second part of the talk will deal with graphene nanoribbons. Due to its semimetal characteristics of graphene's band structure, the on-off ratio in the graphene-based transistor is too low to be useful for practical applications. It has been a long-standing pursuit, to open up and control the bandgap in graphene, by tailoring the graphene into its nanoribbons with atomic precision. Recent advances in bottom-up synthesis in Mainz (in the group of Dr. Akimitsu Narita, Prof. Xinliang Feng and Prof. Klaus Muellen) now allow atomic control of graphene nanoribbons (GNRs) with well-defined bandgap and optical properties. I will present some our recent optical ultrafast conductivity studies on graphene nanoribbons using THz spectroscopy, and show how the conductivity varies with the precise structure of the nanoribbons (*e.g.* the width, and edge structure). [5-7]

References

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