polarization-dependent ultrafast optical response in graphene

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Abstract

Graphene is a two-dimensional crystal of carbon atoms tightly packed in a honeycomb lattice. Owing to its unique optical and electronic properties, graphene is with great potential applications in photonic and electric devices[1]. For graphene to play a significant role in photoelectronic devices, it is vital to understand the optical response and ultrafast carrier dynamics[2]. Understanding the interaction among carriers and carriers with phonons is a major research topic concerning the transient optical properties of graphene[3].

Indeed, the optical response and ultrafast carrier dynamics in graphene and graphite has become a subject of many studies, both theoretical and experimental[2-6]. Although the numerous studies have enhanced our understanding on the optical properties, The experimental results and the interpretations on the carrier dynamics are not consistent. And, the relationship between optical absorbance and polarization is not clear enough.

Here, we study the carrier dynamics of CVD grown multilayered graphene with polarized beams in both degenerate and nondegenerate pump-probe measurement, i.e., probe beam was at wavelength of 800 nm, pump beam was 800 nm or 400 nm[7, 8]. Experimental arrangement and definition of polarization is shown in Fig. 1. In the experiment, differential reflectivity ΔR/R is measured to monitor the carrier relaxation process.

The ΔR/R signal greatly depends on the polarization of probe beam, as shown in Fig. 2. in the whole scan time, ΔR/R is positive if the probe beam is s-polarized, however, if the probe beam is p-polarized ΔR/R is negative. It is the first time to observe positive ΔR/R. the probe polarization dependence of ΔR/R relates to distribution of photoexcited carrier and electric field of probe beam at inclined plane of a BK 7 right-angle prism. The probe polarization dependence could be well explained with Maxwell's equations and the boundary condition of the continuities.

Pump polarization dependence and independence of ΔR/R is observed for the cases of degenerate and nondegenerate, respectively. The pump polarization dependence of signal reflect the anisotropic distribution of photoexcited carriers. What is more, isotropic distribution could be concluded from the pump polarization independence of ΔR/R signal. So, the anisotropic distribution of carrier could disappear with carrier relaxation, become completed isotropic at energetically higher/lower states than pump excitation states.

The polarization dependent study on the carrier dynamics provide the potential way of manipulate transient optical properties.

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Figures

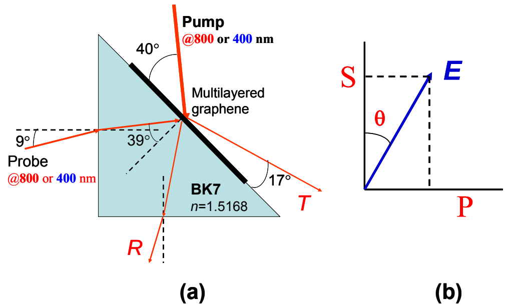

Figure 1. Experimental setups and definition of polarization of beams.

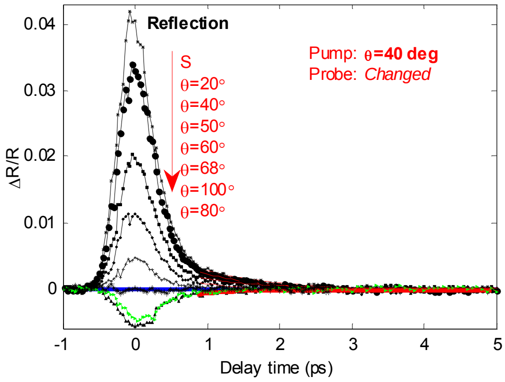

Figure 2. Probe polarization dependence of ΔR/R, pump beam is with wavelength of 800 nm.

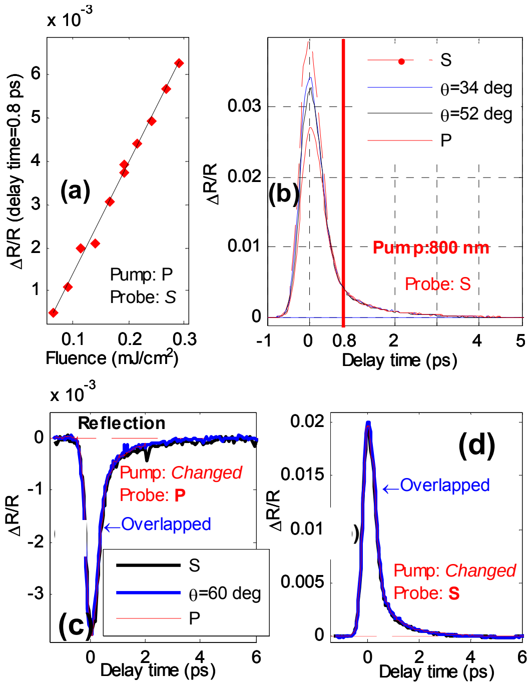

Figure 3. Pump polarization dependence of ΔR/R. (a) pump fluence dependence of ΔR/R signal at delay time of 0.8 ps. (b) pump polarization dependence of ΔR/R time scan curves. (a-b) under 800 nm light excitation. (c-d) ΔR/R time scan for different polarized pump beam under 400 nm light excitation.