Coherent Acoustic Phonon-Defect Scattering in Graphite

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Defects not only play crucial role in the femtosecond relaxation of nonequilibrium carriers but also affect the frequencies and the linewidths of lattice vibrations in semiconductors and metals. In the present study we have examined the effect of lattice defects on the femtosecond relaxation dynamics of coherent acoustic phonon in graphite. The samples were highly oriented pylolytic graphite (HOPG). Point defects were introduced by irradiating the samples with 5 keV He^+. Femtosecond pump-probe reflectivity measurements were performed using the output of a mode-locked Ti:sapphire laser with a pulse duration of 25 fs. A reflected electro-optic sampling (REOS) configuration was employed, in which the anisotropic intensity of the reflected probe beam was recorded. Figure 1 shows a time-resolved REOS signal for unirradiated graphite. The oscillation in the reflectivity corresponds to the interlayer shearing (E_{2g1}) mode of graphite.[1] Upon ion irradiation, the relaxation time *T* was decreased as shown in the inset of Fig. 1. The ion fluence dependence of *T* is explained in terms of scattering of a propagating acoustic phonon by single vacancies,

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{T_v(\phi)} = \frac{1}{T_0} + N_v(\phi)\sigma v_{TA} \qquad (1)$$

where T_0 and T_v are the fluence-independent and the fluence-dependent relaxation times, respectively, N_v the number density of single vacancies that is linearly dependent on ion-fluence ϕ, σ the cross section of a single vacancy, and v_{TA} the group velocity of the acoustic phonon in the long-wavelength limit.

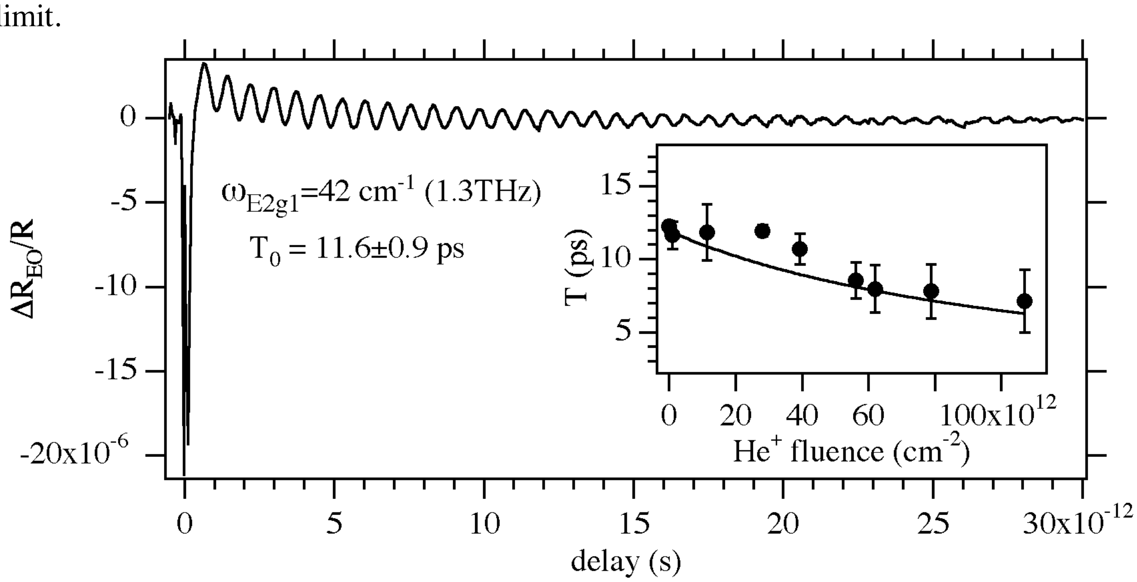

Fig.1 Time-resolved REOS signal for unirradiated graphite. (Inset) The relaxation time of the coherent E_{2g1} phonon of graphite as a function of ion fluence. The solid curve in the inset represents the relaxation time *T* calculated after eq. (1).