Temperature dependence of the anharmonic decay of optical phonons in carbon nanotubes and graphite

IOANNIS CHATZAKIS, Columbia University, New York, NY 10027; Kansas State University, Manhattan, KS 66506,
HUGEN YAN, DAOHUA SONG, STEPHANE BERCIAUD, TONY F. HEINZ, Columbia University, New York, NY 10027 —

We report on the temperature dependence of the anharmonic decay rate of zone-center optical phonons in both single-walled carbon nanotubes and graphite from cryogenic temperatures to 650K. The measurements are performed using a pump-probe Raman scattering scheme with femtosecond (fs) laser pulses [Song et al. PRL 100, 225503(2008)]. A nonequilibrium population of the zone-center (G-mode) optical phonons is created by an initial fs laser pulse. A subsequent fs probe pulse generates both Stokes and antiStokes Raman scattering, from which we infer the mode population of the G-mode phonons. We observe a large nonequilibrium phonon population in both systems, together with a room-temperature population lifetime of 1-2ps. The population decay is attributed to anharmonic coupling to lower-energy phonons [Bonini et al. PRL 99, 176802(2007)]. We observe little T dependence of the decay rate below room temperature, but find a component growing roughly linearly with increasing T for >300K. We compare the behavior observed in nanotubes and graphite and discuss the implications of our results for the mechanism of the anharmonic decay of optical phonons in both systems.

Ioannis Chatzakis
Columbia University, New York, NY 10027; Kansas State University

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