Ultrafast Photogeneration of Coherent Phonons in Ferroelectrics

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The study of the generation of GHz-THz coherent acoustic phonons by femtosecond laser action is a powerful time-domain spectroscopy to evaluate and possibly to control the electron-phonon coupling mechanisms in solids [1]. These fundamental investigations are a key issue for future development of ultrasonic devices providing short acoustic wavelengths (nm) required for advanced nanometrology. Up to now, photo-induced GHz-THz coherent acoustic phonons have been mainly explored in metals and semiconductors as well as in artificial nanostructures [1]. However, despite their inherent strong polarization (providing natural asymmetry) and superior piezoelectric properties, ferroelectric oxides have been regarded only recently [2-5]. Here by using ultrafast pump-probe optical measurements, we report that photo-generation/photo-detection of small band-gap $BiFeO_3$ ferroelectric leads, at room temperature, to spectacular larger GHz coherent shear acoustic wave signal (TA mode) than that coming from longitudinal mode (LA mode), as never reported in any material before [6]. The detailed analysis of the data indicates that this singular behavior comes from an efficient light-induced inverse piezoelectric mechanism. In particular, this piezoelectric effect is governed by the screening of the internal electric fields in BFO driven by light-induced charges. This giant photoacoustic response opens new perspectives for the use of ferroelectric oxides in ultrahigh frequency acoustic devices and the development of new GHz-THz acoustic sources.

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