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Optical control of coherent phonons in bismuth

J.C. Delagnes, K. Hosaka, H. Katsuki, H. Chiba, K. Ohmori,
NINS, IMS, Department of Electronic Structure,
38 Nishigo-Naka, Myodaiji, Okazaki 444-8585

K. Watanabe, Y. Matsumoto
NINS, IMS, Research Center for Molecular-scale Nanoscience,
38 Nishigo-Naka, Myodaiji, Okazaki 444-8585

K. Ishioka, M. Kitajima
Materials Engineering Laboratory, National Institute for Material Science,
Tsukuba 305-0047

K.G.Nakamura
Materials and Structures Laboratory, Tokyo Institute of Technology,
R3-10, 4259 Nagatsuta, Midori,
Yokohama 226-8503, Japan

Abstract

The vast and far-reaching area of coherent control has been successfully demonstrated and implemented in atomic and molecular systems in the gas phase. For instance, the combination of optical and quantum coherences allow us to observe and fully manipulate quantum wave-packets in space and time[1, 2]. Introducing similar ideas to heavily decoherable systems is challenging. We have recently started investigating optical control of coherent phonons in solid-state systems. This new challenge may provide an insight into coherence and decoherence in the many-bodied system in the condensed phase. It is also expected to serve as a powerful tool for understanding the fundamental mechanism of the interaction between a photo-excited single particle (carrier) and the constituents of the surrounding lattice[3]. Optical manipulation of coherent phonons has already been achieved by Murray *et al.* [4] based on double-pulse excitation, but can be classified as "classical" dynamical control (classically kicked pendulum).

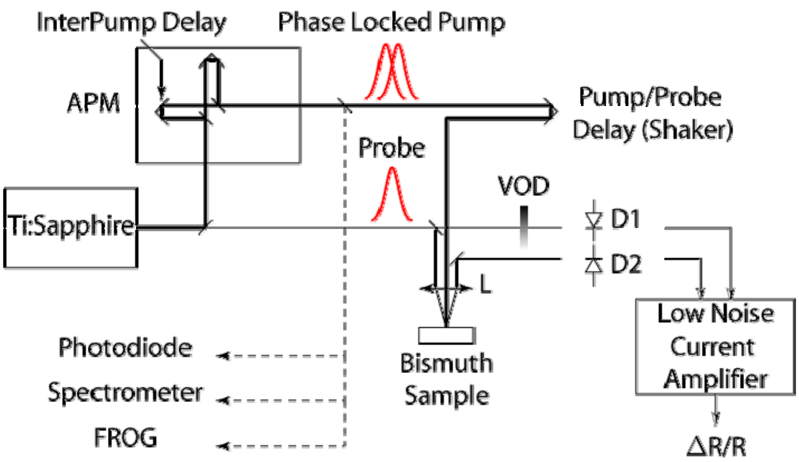

Fig. 1: Experimental setup for the optical control and detection of LO-phonon: A femtosecond oscillator is used to generate pump and probe at 800nm central wavelength. The two phase-locked pump pulses are generated with an APM (attosecond phase modulator). The induced transient probe reflectivity changes of Bi sample are detected with a balanced photodiode scheme.

In our experiment (see Fig. 1), a bismuth sample is irradiated with a phase-locked femtosecond (fs) laser pulses, and its subsequent reflectivity change is monitored in real-time by using a standard fs pump-probe scheme with balanced photodiode optical detection. We use a highly stabilized Michelson-type interferometer (APM[2, 5] : *Attosecond Phase Modulator*) to generate the pair of phase-locked pump pulses. This APM allows us to control the interpulse delay (relative phase) with an attosecond stability and resolution. In this measurement we expect that we gain more insight into the controversial [6] coherent phonon generation mechanism(s) and have access to an accurate investigation of carrier dynamics. We are finally aiming at actively controlling (coherent control, closed-loop approach …) and manipulating the 2D image associated with coherent phonon oscillation (relative phase vs. pump-probe delay).

References

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