Femtosecond non-equilibrium dynamics in phase-change materials

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ABSTRACT

Irradiation of femtosecond laser pulses to solid-state materials induces non-equilibrium electronic states, whose structural properties are far from equilibrium states because of effective electron-lattice coupling, e.g., exciting electrons from bonding into anti-bonding states would lead to the breaking of longer (weaker) bonds in phase-change materials [1-3]. Under such the non-equilibrium electronic conditions, one expects that atomic rearrangements are possible to occur, depending on the electronic excitation density. We have so far investigated both lattice and spin dynamics in phase-change materials under non-equilibrium conditions to realize ultrafast all optical switching of optical data storage media, such as $Ge_2Sb_2Te_5$ (GST225) [4-10]. Interfacial phase-change memory (iPCM) is more interesting material than GST225, in a sense that it would be easier to realize ultrafast lattice and spin switching, based on dominant atomic rearrangement of Ge atoms near the interfaces of superlattice (SL) structure [11]. In this talk, I present very recent results on ultrafast lattice response of phase-change materials in optical communication wavelength. In the study, an amplified femtosecond pulse laser with 40-fs duration was converted into infrared light pulses (~1600 nm) to demonstrate enhancement of lattice vibrations of GST225. I would mention also on recent results for femtosecond spin dynamics in topological insulators, such as Sb_2Te_3 based on time-resolved magneto-optical Kerr-rotation (MOKE) [8]. We demonstrate that transient magnetization by femtosecond laser pulses is possible to occur in topological insulators, whose polarization dependence is strongly governed by the thickness of the sample. We argue that this effect is due to a quantum phase transition between normal and topological insulators.

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