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Photoinduced dynamics in ferroelectric semiconductor $Sn_2P_2S_6$

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The possibility of switching the order parameter in ferroics by means of an electromagnetic pulse is currently one of the most studied topics in the field of interaction of laser radiation with matter. The application of this technology to ferroic materials will probably allow the creation of new high-speed and non-volatile storage devices. If the switching of the magnetization by a single femtosecond laser pulse has already been demonstrated, the problem of the ultrafast ferroelectric switching of the order parameter has not yet been solved. It is established that ultrafast switching of magnetization is determined by spin-orbit and exchange interactions. There are no such mechanisms in ferroelectric materials.

Currently, there are several works in which attempts are made to switch the ferroelectric polarization using medium infrared pulses [1,2]. One of the first steps towards all-optical magnetic order parameter switching was photo-induced excitation of spin oscillations at the magnetic resonance frequency near the phase transition 8. The study of the excitation of photoinduced phonon soft modes in ferroelectric materials is a similar step to the all-optical control of the ferroelectric order parameter.

The class of ferroelectric semiconductors is very important for such studies. One of the most typical representatives of this material is tin hypothiodiphosphate $Sn_2P_2S_6$ (SPS). Studies of the effects of femtosecond laser pulses on an SPS crystal were presented by us earlier [3,4] The first experimental results of photoinduced excitation of phonon modes in an SPS crystal were presented by us in [5]. It was shown that two phonon modes can be excited in an SPS crystal with femtosecond laser pulses with the energy of 3.1 eV at room temperature. One of them was attributed to the phonon acoustic mode with a frequency of 20 GHz. The other, with a frequency of 0.89 THz, was attributed to the soft mode. The latter belongs to A′ symmetry group in the ferroelectric phase and transforms into the Bu symmetry mode in the paraelectric phase. In addition, we demonstrated [6] that the effect of femtosecond laser pulses on SPS did not lead to a local crystal heating or a change in the Curie temperature in the time range up to 10 ps.

Here we present the results of a study of the phonon mode parameters and other photorefractive effects inducing in an SPS single crystal by femtosecond laser pulses in the vicinity of the phase transition and at room temperature. It is shown that the response of a crystal to a laser pulse reminds a soft mode near the phase transition. However, the observed decrease in the frequency of oscillations in the vicinity of the Curie temperature Tc is much weaker than previously reported. This can be explained by the shading of pure soft mode by its interaction with other photo-induced modes.

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