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Ultrafast Photogeneration of coherent acoustic phonons in nanostructured multiferroics

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Photogeneration of coherent acoustic phonons is based on the transformation of the light energy into a mechanical energy [1,3]. This process is driven by the electron-phonon and photon-phonon couplings that are known generally to be large in ferroic compounds [1,3]. While most of the investigations have been conducted in bulk materials [1,4-6], we present recent experiments where photoinduced strain is evaluated in nanostructured $BiFeO_3$-based multiferroic materials. We investigate different nanostructured multiferroic systems such as $BiFeO_3$-based superlattices (SLs) [7] and self-organized stripe domain patterns of $BiFeO_3$ thin films [8,9]. We demonstrate it is possible to generate and detect coherent acoustic phonon modes near the center of the Brillouin zone up to THz in $BiFeO_3$/$LaFeO_3$ superlattices. The physical origin of the observed two modes (0.7 THz and 1.2 THz) is discussed in relation with the chemical and polar orders analyzed with X-ray diffraction, resonant X-ray reflectivity and high-resolution transmission electron microscopy. In the second system, we investigate GHz acoustic phonon generation in self-organized stripe domain patterns of $BiFeO_3$ thin films [8,9]. By comparing the ultrafast photostriction process in a $BiFeO_3$ single domain and that in a stripe domain sample, we evidence the crucial role of the presence of multiple domain walls in the coherent acoustic phonon generation process.
All these new results are important for envisioning the use as on-purpose ferroic architectures in devices like actuators or acousto-optic modulators with ultra-short light pulses.

References

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