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Surface phonon fields in phononic crystals with arbitrarily-positioned point source

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1. Introduction

The band structure of phonon modes in a periodic structure, or phononic crystal, provides a useful means of controlling phonon propagation. Such modes in phononic crystals have been theoretically and experimentally studied in both the temporal and frequency domains using various methods. In practice the excited modes depend on the nature of the excitation with respect to the material structure. However the effect of varying the excitation for a given structure has not been studied in detail. Here we investigate the effect of varying the excitation source on the vibrational response of a phononic crystal with both finite element time domain numerical simulations and with an experimental approach.

2. Experiment and results

The sample consists of a triangular array air holes in a photoresist material, prepared by three-dimensional diffuser lithography, on a silicon substrate. The holes are hexagonal shaped with a width of 7 μm and spacing 10 μm. To excite the vibrations, we focus ultrashort optical pulses from a Ti:sapphire femtosecond laser of ~800 nm to a point of about 2 μm in diameter on the sample surface to induce thermoelastic expansion. A probe beam at ~400 nm, delayed relative to the pump beam, is used to measure the sample vibrations by interferometry. The probe spot is scanned across the sample while varying the time delay between the pump and probe beams. Using this method we obtain images of surface phonons excited at different locations propagating over the material. We can then extract frequency-resolved vibrational fields by Fourier analysis.

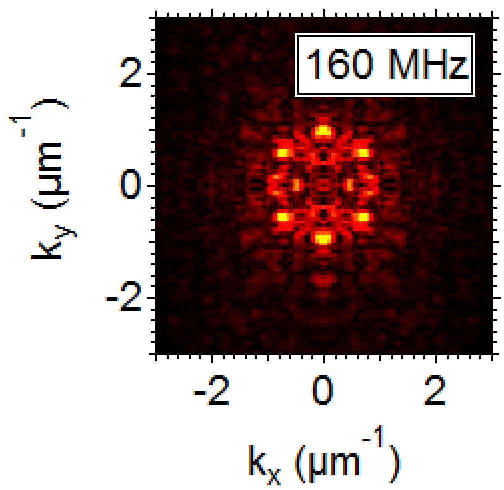

Figure 1 **k**-space image at 160 MHz of the phonon field in a triangular lattice phononic crystal excited at a 2-fold symmetry point.

Figure 1 shows a simulated **k**-space image of the phonon field at 160 MHz excited at a 2-fold symmetry point. This image demonstrates the excited 2-fold symmetry, as well as the influence of the underlying 3-fold structure. We find that in general, the existence of band gaps depends not only on the structure and direction, but also the nature of the excitation. We will present detailed analysis of the phonon propagation resulting from various excitations in this structure. These measurements provide further insight into the complex vibrational behavior of phononic crystals.