

# Supporting information for:

## Engineering the Hypersonic Phononic Band Gap of Hybrid Bragg-Stacks

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## **Preparation of Phononic Bragg-Stacks**

In this work, hybrid phononic stacks were built up on the principle of maintaining a large elastic impedance contrast between the two individual components as well as preserving optical transparency. The phononic crystal was realized by building up a 10 bilayer Bragg stack of alternating inorganic silica and poly (methyl methacrylate) (PMMA) layers. Silica nanoparticles provided the high elastic modulus with PMMA possessing the low modulus, to achieve the desired contrast in the hybrid structure. The layers are spin-coated on glass substrates which have been cleaned earlier in acidic piranha solution comprising concentrated sulphuric acid and hydrogen peroxide (30%) mixed in a volume ratio of 2:1. A 10 bilayer sequential phononic stack of PMMA/p-SiO<sub>2</sub> is built up by spin coating from a 2.2% (w/v) PMMA (Acros, MW 35 kDa) in toluene solution and a 3.4% Silica (LUDOX AS-30, Aldrich ) solution having small additions of 0.1% sodium dodecyl sulphate and 14% ammonium hydroxide. Concentration of the solutions has been optimized to yield an individual layer thickness of 50 nm. In case of PMMA, the thickness was analyzed by a Profilometer (Model P16+, KLA-Tencor, Software v. 7.21) while ellipsometry was done to determine an optimum Silica layer thickness. Spin coating was carried out using a Laurell WS-400-6NPP-LITE instrument using fixed coating parameters of a speed of 5000 rpm, an acceleration of 5040 rpm/s for 20 seconds for each layer. Subsequent to the coating, each layer undergoes heat treatment at 100 °C for 15 min to evaporate the solvents. The cross-sectional scanning electron microscopy (SEM) images indicate the periodicity over the whole 10 bilayers stack showing homogeneous layers.

## **Electron Microscopy**

The prepared Bragg-Stacks were characterized by SEM on a LEO Gemini 1530 microscope (Carl Zeiss AG, Oberkochen, Germany) with acceleration voltage of 0.7 kV in secondary electrons In-Lens detection mode. The obtained pictures are the basis for an estimation of layer spacing and volume fraction of the composing materials.

## Confocal Microscopy

A confocal microscope (NanoFocus<sup>®</sup>  $\mu$ Surf<sup>®</sup>) was used to determine total thickness of the stacks. This robust method uses a white light confocal measurement head that is moved stepwise in  $z$ -direction. The stacks were scratched near the position of BLS measurement and the  $z$ -difference between substrate and sample surface indicated the actual total thickness.

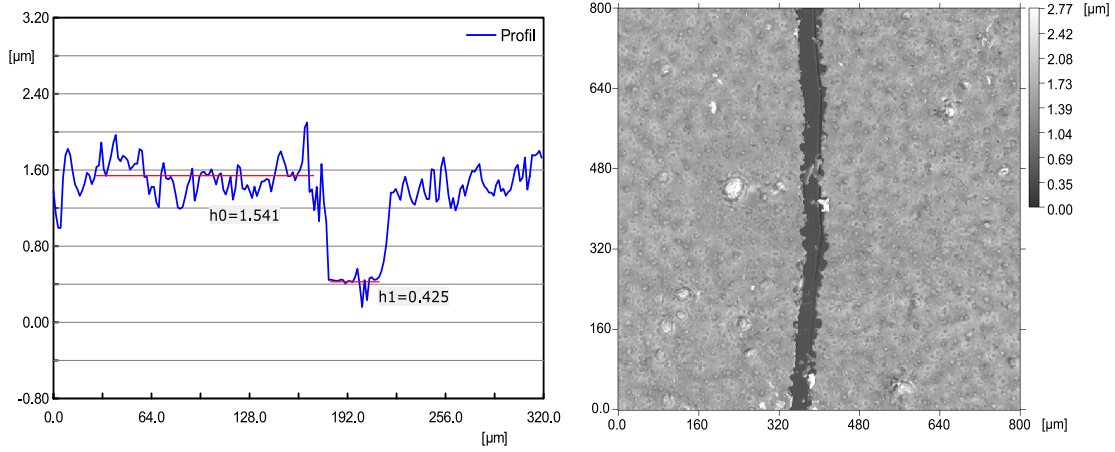


Figure S1: Profile and height image of stack A obtained by confocal microscopy. The difference in height between the bottom of the scratch and the top level defines the total thickness  $d$ .

## BLS spectroscopy

Brillouin light scattering (BLS) spectroscopy is a powerful non-destructive technique that leverages the Doppler-shift of light scattered inelastically and spontaneously from thermally activated hypersonic (GHz) elastic waves, generally referred to as phonons. This frequency shift together with the adjustable scattering geometry allows for the direct measurement of the phononic dispersion relation  $\omega(k)$ , from which sound velocities and confinement effects in mesostructures can be deduced. The detection of very small shifts is realized by a tandem Fabry-Pérot interferometer, where the incoming light has to pass an etalon for six times, discriminating light of all wavelengths that doesn't fulfill  $m\lambda_0 = 2nd$ . Whereas  $m$  is a positive integer,  $\lambda_0$  the wavelength of the incoming light,  $n$  the refractive index of the etalon material and  $d$  its thickness. By changing the thickness of the etalon  $d$  (movement of one mirror) various free spectral ranges (distance  $\Delta f_{FSR}$  between peaks

of different order  $m$ ) are accessible. The resolving power is quantified by the finesse  $F = \frac{\Delta f_{FSR}}{\Gamma_{FWHM}}$  ( $F \sim 60$  in the current setup), whereas  $\Gamma_{FWHM}$  is the instrumental width at half maximum. The higher  $F$ , the more details can be resolved in the spectrum  $I(\omega, q)$ .

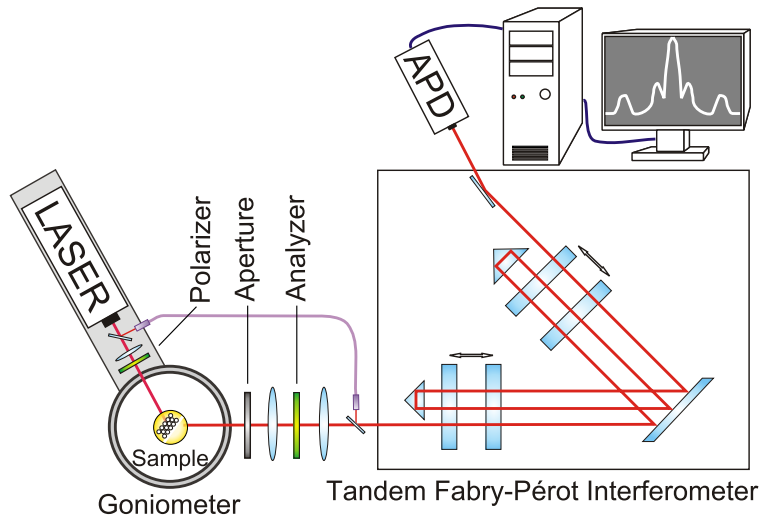


Figure S2: Scheme of setup used for Brillouin spectroscopy. The Doppler-shift of light scattered inelastically and spontaneously from thermally activated hypersonic phonons is detected by a tandem Fabry-Pérot interferometer.