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This dataset supports the publication: Optical Control of Nanomechanical Brownian Motion Eigenfrequencies in Metamaterials

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Contents

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This research data description should be read and understood in the context of the corresponding manuscript. The figure numbers correspond to the figure numbers of the manuscript and the data corresponds to the data as shown in the figures.

The figure descriptions as given in the corresponding manuscript are given below.

The file contains the data for figures 1c, 2, 4, and S1.

[Figures 1a,b are schematic diagrams; Figure 3 is derived from the data of Figure 2]

Figure 1. Detecting thermal (Brownian) motion of nanowires within an all-dielectric nanomechanical metamaterial. (a) Scanning electron microscope image of the metamaterial, fabricated on a 20.5 μm wide free-standing silicon nitride membrane. The inset enlarged section shows detail of the supported silicon nano-bricks – the dashed line denotes a unit cell of the structure. (b) Schematic of experimental apparatus for recording frequency spectra of metamaterial transmission. Other than between the two collimators, light is carried in polarization-maintaining single-mode optical fiber, with the MEMS switch providing for inversion of the light propagation direction through the sample. (c) Exemplar measurement of optical transmission amplitude spectral density [for light incident on the silicon nitride side of the sample at a power level of 15.9 μW], showing a pair of peaks associated with the mechanical resonances of two individual nanowires within the array: ①/② a narrower/wider wire decorated with shorter/longer Si bricks. The overlaid magenta curve and calibrated displacement spectral density scale [to the right-hand side] are obtained by fitting Eq. (1) to the experimental data. Derived values of f0, Q and meff are shown inset.

Figure 2. Optical control of nanowire Eigenfrequencies. Transmission amplitude spectral density, showing peaks ① and ② as assigned in Fig. 1c, for opposing directions of light propagation through the sample – (a) forward and (b) backward [light incident respectively on the silicon and the silicon nitride side], and for a range of laser power levels [as labelled].

Figure 3. Optical control of nanowire Eigenfrequencies and Brownian motion amplitudes. Dependences for peaks ① and ② in Fig. 2 [i.e. for narrow and wide nanowires as identified in Fig. 1c, under nominally forward and backward directions of illumination] of (a) resonance frequency, (b) RMS displacement amplitude, and (c) light-induced nanowire temperature change on incident laser power [total power incident on the metamaterial sample]. Square symbols are experimental data points, with error bars given by the standard deviation over three repeated measurement cycles. Solid lines are derived from an analytical description of the photothermal tuning mechanism via a simultaneous best-fit to the four experimental datasets in (a).

Figure 4. Optical control of nanomechanical motion - thermal and non-thermal mechanisms. Amplitude spectral density of probe transmission (in the forward direction) for a range of pump peak power levels, with a fixed pump modulation frequency.

Fig. S1: Spectral dispersion of metamaterial transmission T and reflection R measured using a microspectrophotometer, and absorption A calculated as [100-(T+R)], for incident light polarized parallel to the nanowires. Spectra are measured for the two different directions of light propagation (nominally forward and backward) through the sample by removing it from the instrument, turning it over, and reinserting it. Resulting positional alignment imperfections account for the small discrepancies between the two transmission spectra (which would be identical in an ideally reciprocal pair of measurements).

Geographic location of data collection: University of Southampton, U.K.

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