Tailored optomechanical couplings in heterogeneously integrated photonic crystal system

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Photonic crystals (PhC) are widely employed as a platform for optomechanics [1]. Tapered fibre approach is often used with such systems for achieving optical coupling with the resonator, which only allows for addressing one cavity at a time. We propose and study [2] a new optomechanical platform featuring a III-V semiconductor PhC layer, suspended over and coupled to a silicon-on-insulator (SOI) waveguide. One of its key advantages is the possibility to address multiple optical cavities embedded into one or multiple mechanical resonators, being ultimately suitable for optomechanical arrays experiments [1].

We demonstrate optomechanical resonators consisting of a L_3 PhC nanocavity etched into a thin InP membrane, heterogeneously integrated onto a SOI waveguide substrate (Fig. 1a,b). Flexural mechanical modes in the MHz range are systematically observed on the investigated devices (Fig. 1c) and exhibit tailored dispersive and dissipative optomechanical couplings [3]. The optomechanical response of such modes consistently showed that the most significant contribution to the optomechanical transduction was of dissipative nature. We observe a different relative sign of the dispersive and dissipative coupling coefficients by varying the access waveguide width, allowing to finely tailor the optomechanical coupling strength between the devices within one sample. Simulations also demonstrate that our system has an additional way to coarsely tune both types of couplings by changing the suspension height of the III-V semiconductor layer [3]. Demonstrated tailored optomechanical couplings in our integrated devices therefore pave the way to an optimal mechanical mode cooling in the unresolved-sideband regime [4].

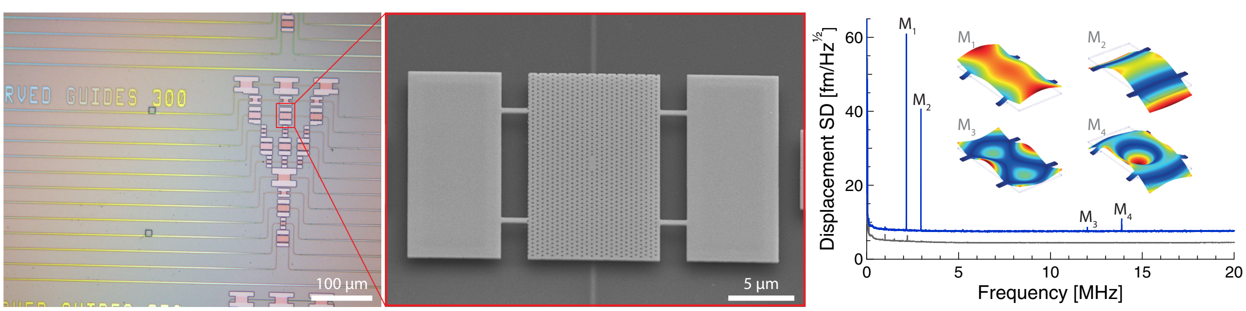

Fig. 1 – **a.** Top view optical micrograph of a chip holding an array of PhC membranes, suspended over their corresponding access waveguides. **b.** Close-up SEM image of a single membrane. **c.** Brownian motion spectrum of a PhC membrane resonator (blue curve: probe laser tuned to the optical cavity resonance; grey curve: probe laser tuned out of optical cavity resonance). Insets: normalised displacement field patterns for four low-frequency vibration modes, computed by finite element modelling.

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