フォノニック結晶共振器と導波路を用いたマグノメカニクス素子
A magnomechanical device based on a phononic crystal cavity and waveguide

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Magnomechanics is promising technology in the fields of magnonics and phononics because magnons (phonons) can implement the distinctive property of phonons (magnons) via the interaction [1]. It holds promise for improving their characteristics and controllability, e.g, improved coherence of magnons and generation of magnetically-susceptible phonons. Recently, important achievements have been made using a surface acoustic wave (SAW) where the hybrid interaction between GHz vibrations and spin-wave resonances were investigated that developed novel device functionality like nonreciprocal propagation [1,2]. However, the SAW-based phononic cavities used in these studies have a large device footprint (~mm^2) [3]. To implement the magnomechanics technology in magnonic and phononic integrated circuits, a smaller cavity architecture is highly desired. Here we report a novel magnomechanical device based on a wavelength-scale (~μm^2) phononic crystal (PnC) cavity and its magnomechanical characterization at room temperature.

The device is composed of mainly three components: inter-digit transducers (IDTs), a PnC cavity formed in a GaAs membrane, and a nickel (Ni) film on the cavity as shown in Fig. (a). The cavity is created by removing two air-holes from the PnC lattice [4] and the resonant vibrations are excited via the IDTs at 0.581 GHz with a defined mode profile as shown in Fig. (b). When a static magnetic field ($\mu_0 H_{\rm ex}$) is applied in-plane to the Ni film, and the magnitude is swept from 60 mT to -60 mT, the resonant frequency and Q-factor are modulated as shown in Fig. (c). The theoretical calculations clarify that these observations result from the back-action of spin-wave resonances in the Ni film. To the best of our knowledge, this is a first demonstration of the magnomechanical hybrid device formed in a wavelength-scale PnC cavity. Such a compact and spatially-flexible platform will be an essential element for an integrated magnomechanical circuit.

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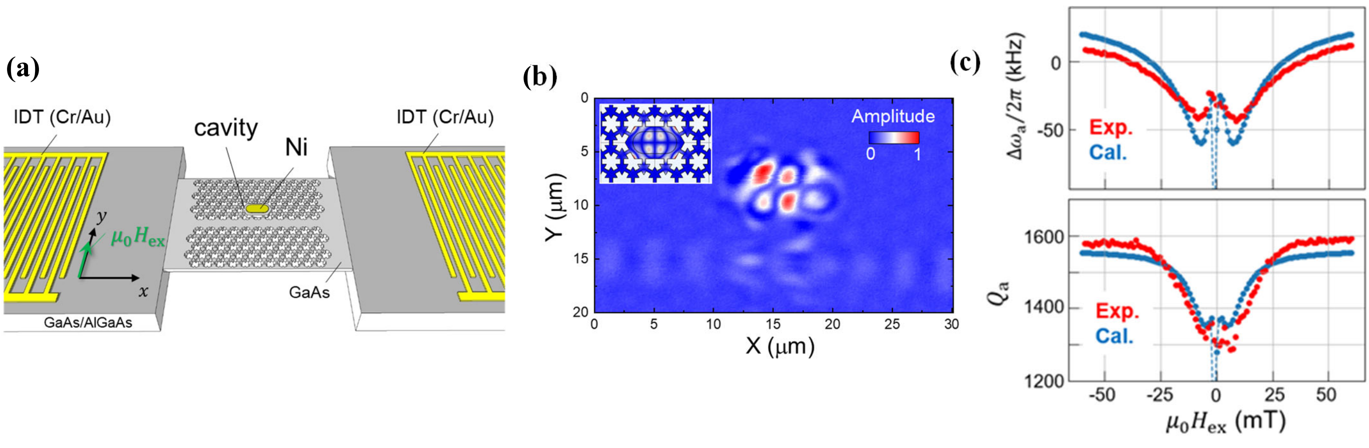

Fig. (a) Schematic of a PnC cavity with a Ni film (50 nm-thick). An external field ($\mu_0 H_{ex}$) is applied along y-axis. **(b)** Experimental resonant mode profile at 0.581 GHz. The inset shows the numerically calculated mode profile. **(c)** Field dependence of the resonant frequency shift (top) and quality-factor (bottom) in the PnC cavity. The experimental and calculated results are plotted by red and blue dotted lines respectively.